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DEPARTMENT OF THE INTERIOR
HAROLD L. ICKES, SECRETARY

BUREAU OF MINES
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INFORMATION CIRCULAR

# SOME ASPECTS OF STRIP MINING OF BITUMINOUS COAL IN CENTRAL AND SOUTH CENTRAL STATES

BY

ALBERT L. TOENGES AND ROBERT L. ANDERSON

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DEPARTMENT OF THE INTERIOR - BUREAU OF MINES

# SOME ASPECTS OF STRIP MINING OF BITUMINOUS COAL IN CENTRAL AND SOUTH CENTRAL STATES[1]

By Albert L. Toenges[2] and Robert L. Anderson[3]

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## INTRODUCTION

The production of bituminous coal by stripping methods has become an important factor in some areas, especially in the Central and South Central States. In the latter, production at strip mines exceeds that at deep mines. Table 1 shows the tonnage produced at strip mines and the percentage of the total production for 1924 to 1935, inclusive, for the States in which the mines described in this circular are situated.4/ Following are references to earlier Bureau of Mines publications on strip mining of bituminous coal:

> Cash, F. E., and von Bernewitz, M. W., Methods, Costs, and Safety in Stripping and Mining Coal, Copper Ore, Iron Ore, Bauxite, and Pebble Phosphate: Bull. 298, Bureau of Mines, 1929, 275 pp.
>
> Kiessling, O. E., Tryon, F. G., and Mann, L., The Economics of Strip-Coal Mining: Econ. Paper 11, Bureau of Mines, 1931, 32 pp.
>
> Turner, Scott, and Bureau of Mines Staff; Mining Bituminous Coal by Stripping Methods: Inf. Circ. 6383, Bureau of Mines, 1930, 23 pp.

Shallow coal, which could not be mined economically by underground methods because it is thin and because of roof conditions, is being mined successfully by stripping. Because of the growing importance of strip mining to the coal industry, not only in point of production but also in regard to conservation of natural resources, the mining methods and practices in use in some strip mines of western Pennsylvania, Ohio, Indiana, Illinois, Missouri, and Kansas were investigated. Man-hour costs for a working day have been computed for individual mines, and total mine costs for labor, power, and supplies are given in percentage of total mine cost for various ratios of overburden to tons uncovered. Costs in strip mines vary greatly from month to month due to changing physical conditions and mechanical difficulties. The latter, however, have been minimized by the latest equipment. Percentage costs therefore, have, been computed over a period of several months but should not be taken as a criterion.

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4/ U. S. Bureau of Mines Coal Statistics.



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Table 1.- Bituminous coal produced by strip mining in certain States

| | | Pennsylvania | Ohio | Indiana | Illinois | Missouri | Kansas | United States |
|---|---|---|---|---|---|---|---|---|
| 1924: | Tons | 902,818 | 2,866,683 | 2,511,189 | 2,295,860 | 979,700 | 795,074 | 13,606,954 |
| | Percent[1] | 0.7 | 9.4 | 11.7 | 3.4 | 39.5 | 18.7 | 2.8 |
| 1925: | Tons | 800,615 | 3,059,324 | 3,269,386 | 3,398,159 | 1,202,201 | 1,123,550 | 16,870,907 |
| | Percent[1] | 0.6 | 10.9 | 15.4 | 5.1 | 44.6 | 24.8 | 3.2 |
| 1926: | Tons | 1,012,400 | 2,538,455 | 3,617,236 | 3,466,098 | 1,243,723 | 1,282,426 | 16,922,695 |
| | Percent[1] | 0.7 | 9.1 | 15.6 | 5.0 | 41.4 | 29.0 | 3.0 |
| 1927: | Tons | 1,151,990 | 2,695,152 | 4,456,324 | 2,814,024 | 1,484,902 | 1,251,543 | 18,378,166 |
| | Percent[1] | 0.9 | 17.1 | 24.8 | 6.0 | 48.5 | 36.3 | 3.6 |
| 1928: | Tons | 1,076,871 | 2,373,704 | 4,823,012 | 4,339,442 | 1,778,507 | 1,206,420 | 19,788,577 |
| | Percent[1] | 0.8 | 15.2 | 29.4 | 7.8 | 47.6 | 42.9 | 4.0 |
| 1929: | Tons | 649,885 | 1,767,681 | 5,613,108 | 5,374,813 | 1,986,297 | 1,021,639 | 20,268,099 |
| | Percent[1] | 0.5 | 7.5 | 30.6 | 8.9 | 49.3 | 34.4 | 3.8 |
| 1930: | Tons | 699,040 | 1,118,203 | 5,639,212 | 6,116,415 | 2,070,201 | 1,046,601 | 19,842,359 |
| | Percent[1] | 0.5 | 5.0 | 34.2 | 11.4 | 53.7 | 43.1 | 4.3 |
| 1931: | Tons | 441,972 | 941,910 | 5,304,894 | 6,325,597 | 2,308,363 | 1,153,159 | 18,932,381 |
| | Percent[1] | 0.4 | 4.6 | 37.1 | 14.3 | 63.8 | 58.0 | 5.0 |
| 1932: | Tons | 224,512 | 805,300 | 5,790,857 | 6,551,301 | 2,577,219 | 1,183,544 | 19,641,128 |
| | Percent[1] | 0.3 | 5.8 | 43.5 | 19.6 | 63.3 | 60.6 | 6.3 |
| 1933: | Tons | 266,172 | 1,006,204 | 5,065,076 | 5,624,632 | 2,147,260 | 1,439,529 | 18,270,181 |
| | Percent[1] | 0.3 | 5.1 | 36.8 | 15.0 | 62.6 | 64.9 | 5.5 |
| 1934: | Tons | 342,098 | 1,201,416 | 6,000,613 | 6,160,083 | 2,190,056 | 1,747,110 | 20,789,641 |
| | Percent[1] | 0.4 | 5.8 | 40.6 | 14.9 | 65.3 | 69.7 | 5.8 |
| 1935: | Tons | 434,463 | 2,048,399 | 6,521,414 | 7,410,087 | 2,351,288 | 1,740,319 | 23,647,292 |
| | Percent[1] | 0.5 | 9.7 | 41.4 | 16.6 | 64.5 | 64.8 | 6.4 |

[1] Percent of strip coal of total State production.

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Acknowledgment

The information used in preparing this circular was obtained through the courtesy and cooperation of the officials of the companies whose mines are described and from officials of the Marion Steam Shovel Co. and Bucyrus-Erie Co. The approval of the executive of each property was obtained for publishing this manuscript, and its accuracy was checked.

## WESTERN PENNSYLVANIA AND EASTERN OHIO

### General Description of Area

This area includes Washington County, Pa., and Harrison, Jefferson, and Muskingum Counties, Ohio. The topography is generally hilly. In some places the hills reach an elevation of 500 feet above the valleys. The slope of the hillsides is generally moderate but in some places exceeds 10 percent. Since the coal seams mined outcrop on the sides of the hills above the valleys, the slope of the hillsides is a factor that limits the width of the stripping area.

Mines in the area are served by the Pennsylvania, New York Central, Wheeling & Lake Erie, and Pittsburgh & West Virginia Railroads. The production from some mines is loaded from the tipple into barges and transported on the rivers.

### General Geology

The coal seams mined are the Pittsburgh or Ohio No. 8 seam and the Middle Kittanning or Ohio No. 6.

The Pittsburgh seam at the mines visited ranges from 36 to 60 inches in thickness. Typical sections of the seam as found are as follows:

Section A:

| | |
|---|---|
| Coal | 12 inches. |
| Bone | 1 to 4 inches. |
| Coal | 38 to 40 inches. |

Section B:

| | |
|---|---|
| Coal | 36 to 40 inches. |

Section C:

| | |
|---|---|
| Roof coal | 6 to 18 inches. |
| Draw slate | 10 to 12 inches. |
| Bone | 1 inch. |
| Coal | 18 inches. |
| Shale parting | ¼ inch. |
| Coal | 4 to 6 inches. |
| Shale parting | ¼ inch. |
| Coal | 36 inches. |



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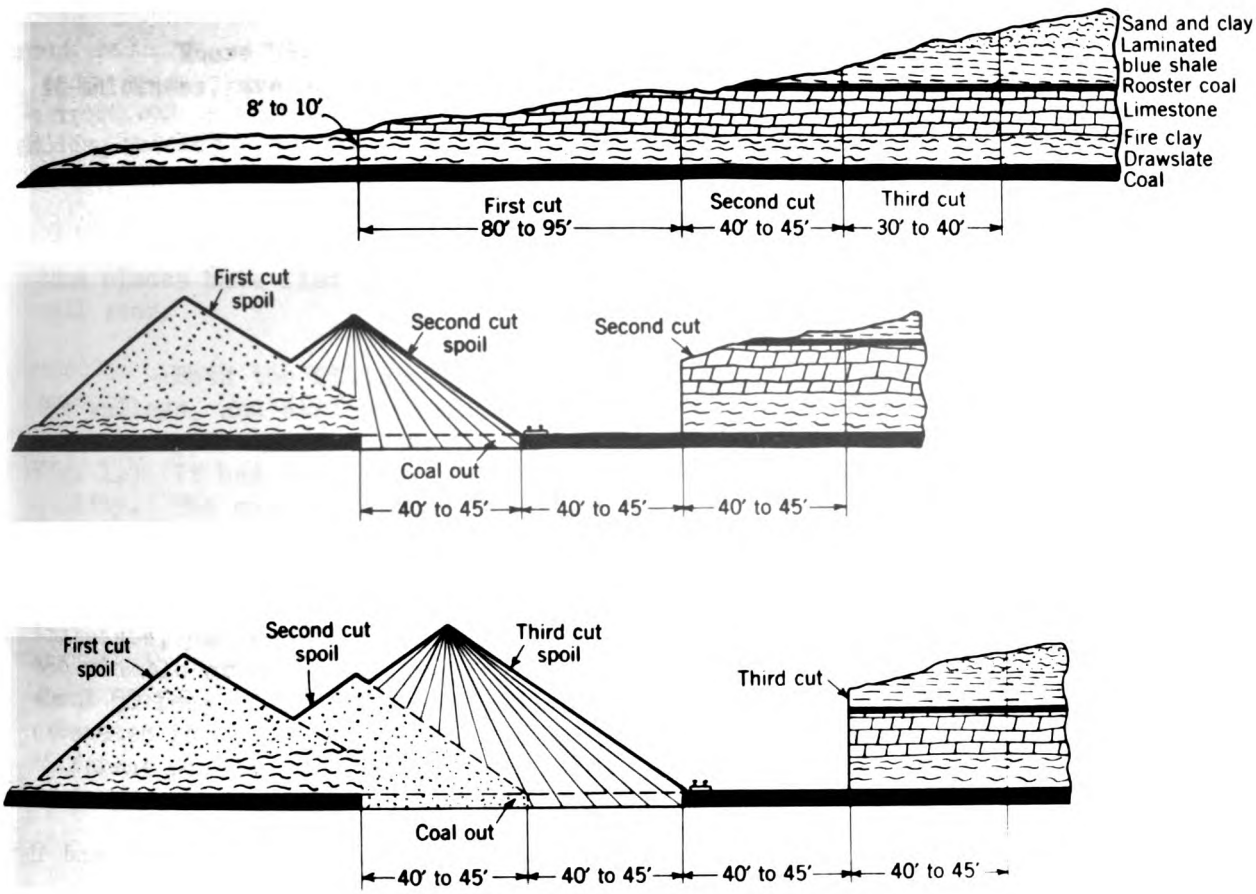
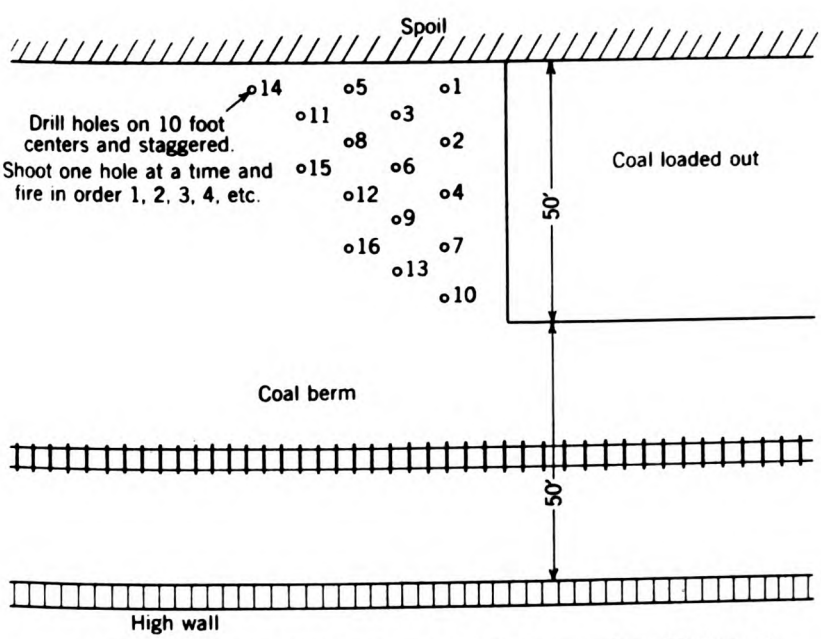



A. Method of opening strip mine near outcrop.




B. Arrangement and spacing of holes and shooting to obtain blocky coal.

Figure 1.

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Where No. 6 seam is mined it ranges from 22 inches to 38 inches in thickness, averaging 36 inches. A section is as follows:

| | |
|---|---|
| Coal | 12 inches. |
| Parting | 1 to 1½ inches. |
| Coal | 24 inches. |

Some places have flat pieces of shale and pyrite 14 inches below top of the coal seam.

Both the Pittsburgh and No. 6 seams outcrop on the hillsides above the valleys, and stripping usually begins with an opening cut back from the the outcrop, where the overburden averages 8 to 10 feet in thickness. (See fig. 1.) It has been found that the coal under less cover is inferior in quality. The coal seams, although having a slight regional dip, lie comparatively level. There are local dips, but these are not general.

As operations advance away from the outcrop the depth of cover increases, and thus the slope of the hillside will determine the width of the minable area. The economic limit of stripping in these areas has been about 50 feet of overburden, although in isolated cases 72 feet has been excavated for short distances. The character of the overburden varies at different places even in the same mine, but typical sections are as follows:

Section A:

| | |
|---|---|
| Soil | Varying thickness. |
| Rooster coal | 12 to 24 inches. |
| Shale | 24 feet. |
| Coal (Pittsburgh). | |

Section B:

| | |
|---|---|
| Soil | Varying thickness. |
| Shale | Do. |
| Sandstone | Do. |
| Black shale | 12 feet. |
| Rooster coal | 20 inches. |
| Limestone | 12 to 15 feet. |
| Shale (soft) | 1 foot. |
| Limestone | 2 feet. |
| Shale | 15 feet. |
| Coal (Pittsburgh). | |

Section C:

| | |
|---|---|
| Soil and shales | 22 to 24 feet. |
| Rooster coal | 1 foot 10 inches. |
| Limestone boulders | 15 feet. |
| Shale (soapstone) | 8 inches. |
| Limestone | 1 foot. |
| Shale (soapstone) | 5 feet. |
| Coal (Pittsburgh). | |



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Section D:

| | |
|---|---|
| Sand, clay, and boulders | 10 feet. |
| Laminated shale | 20 feet. |
| Coal | 1 foot 6 inches. |
| Limestone | 8 feet. |
| Brown shale | 8 feet. |
| Coal (Pittsburgh). | |

Section E:

| | |
|---|---|
| Shale | 8 feet |
| Fine-grained sandstone or sandy shale | 0 to 24 feet. |
| Draw slate | 6 to 7 inches. |
| Mud seam | 4 inches. |
| Roof coal | 2 inches. |
| Mud seam | 3 inches. |
| Soft, dirty coal | 1 inch. |
| Coal (No. 6). | |

The stratum beneath these seams is fireclay, shale, or limestone.

## Prospecting

To ascertain the character and thickness of the overburden and coal, a property usually is prospected by diamond drilling, churn drilling, or test pits. Where the coal seam outcrops on the hillside, the thickness and quality can be determined by open-cuts and short drifts. The seams as a rule are persistent and extend through the hills in uniform thickness to the next valley. The thickness and character of the various strata in the overburden are of prime importance in strip mining, because of the varying costs of drilling and blasting different materials.

Figure 2,A, is a general plan of a typical strip area in this region and figure 2,B, shows the location of cuts when an irregular area is mined.

# WESTERN AND SOUTHWESTERN INDIANA

## General Description of Area

The mines described are situated in Gibson, Greene, Pike, Sullivan, Vigo, and Warrick Counties. The topography of the area is generally level to gently rolling, except in the southern part, where the surface is hilly. Many streams drain the area. Where the surface of the land is comparatively level, the outcrop of the minable coal seams is buried, but in the hilly areas the coal outcrops on the hillsides. The shape of these minable areas is irregular, since they conform to the contour of the hills.

The mines described are served by the Chicago, Milwaukee, St. Paul & Pacific; Pennsylvania, Monon, Algers, Winslow & Western; and the Midland Railroads.



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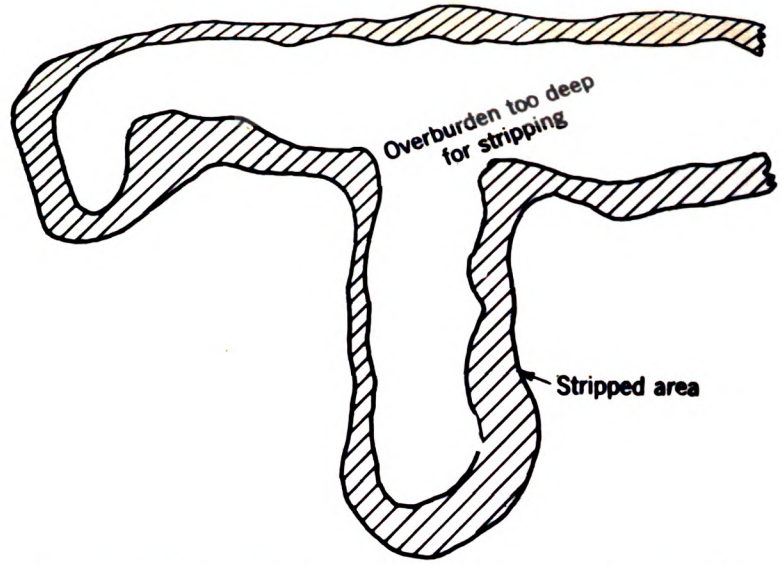
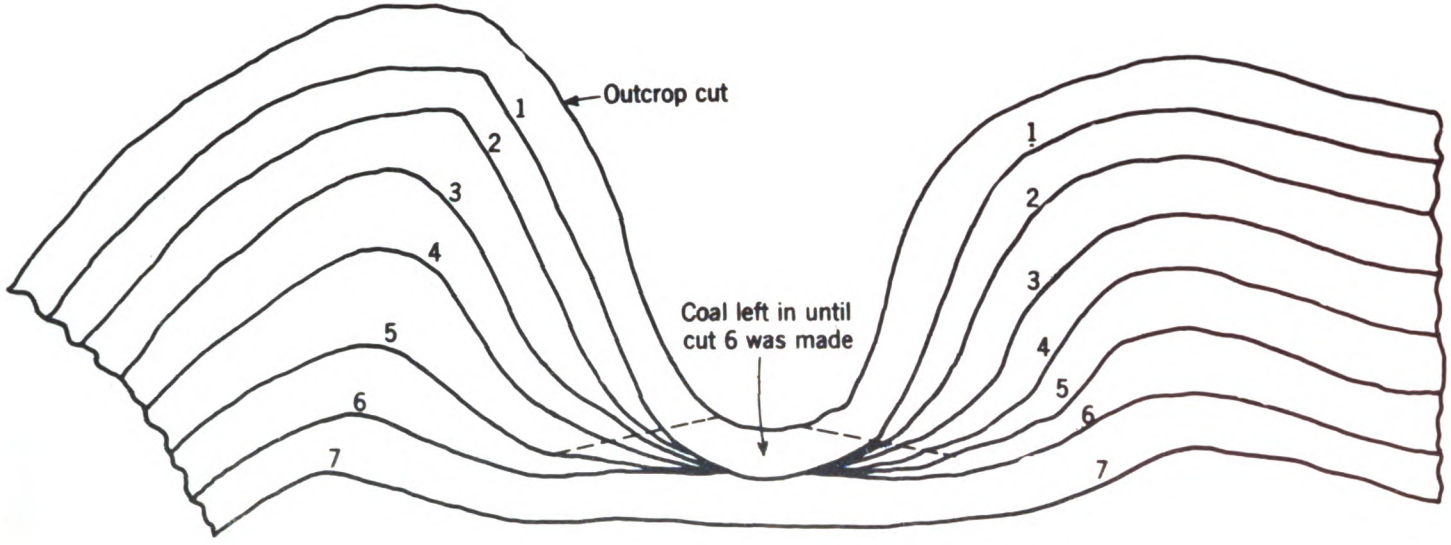



A. Typical stripping area in Western Pennsylvania and Eastern Ohio.




B. Location of cuts when mining an irregular-shaped area.

Figure 2.

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## General Geology

The Indiana Nos. 4, 5, 6, and 7 coal seams are mined at various places in this area.

No. 4 seam, where it is mined, ranges in thickness from 33 to 36 inches. It is clean, except for a parting 2 inches thick which occurs approximately 9 inches below the top of the seam. It is comparatively level, except for the local dips. The strata above the seam vary but usually consist of soil and clay, sandstone, and sandy shale. The bottom is fireclay.

The thickness of No. 5 seam varies. At one mine it averages 3 feet and at another 4 feet 5 inches in thickness. The contour of the seam is irregular. At places, dips of 12° to 14° occur. The extent of these irregularities may be 400 feet before the seam becomes level or changes from a dip to a rise. The average grade, as a rule, is 2 to 3 percent. The overburden consists of soil, sometimes gray sandstone, fireclay, limestone, and hard shale. The bottom is fireclay.

No. 6 seam averages 5 feet in thickness. An average section is as follows:

| | Inches |
|---|---|
| Coal ..... | 18 |
| Shale and bone parting ..... | 2 |
| Coal ..... | 14 |
| Shale and bone parting ..... | 1 |
| Coal ..... | 14 |
| Shale and bone parting ..... | 2 |
| Coal ..... | 9 |
| Total ..... | 60 |

Occasionally there are lenses of pyrite in the coal. The overlying strata comprise shale, sandstone, and surface soil. The bottom is fireclay.

No. 7 seam is being mined at one property and averages 4 feet in thickness. The overburden was composed of hard gray shale, yellow sandstone, and clay. The bottom varied from sandstone to fireclay.

## Prospecting

At virtually all the properties described, hand drills were used to determine the outline of the coal area, the character of the overburden, and elevation of the coal seam. The latter is of prime importance, as it indicates the haulage grades that may be expected after the coal is uncovered and reveals points where the overburden is abnormally thick. At some places holes are drilled 100 feet apart. The drilling outfit consists of a hollow chisel bit attached to lengths of $\frac{3}{4}$-inch pipe. Water is placed in the hole and the cuttings are forced up through the pipe by the churning action of the drill.



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## ILLINOIS

### General Description of Area

Strip mining is being conducted in northern, central and southern Illinois. The topography of the areas is rolling to flat. The coal seams, as a rule, are not exposed on the surface but lie buried. The coal areas are located by drilling either with churn or diamond drills.

The Alton, Illinois Central, Missouri Pacific, and Santa Fe Railroads serve the mines described.

### General Geology

The coal seams mined are Illinois No. 2 (called the Third Vein), No. 5, and No. 6.

No. 2 averages 3 feet in thickness. It is usually free of partings, but there are places in the mine where the coal thins, and at these places there sometimes is a clay parting. The regional dip is southwest, and the seam usually follows this dip, which averages 20 feet to the mile. There are, however, local dips sometimes as great as 10 percent.

The overburden varies in character and thickness. It consists of soil, sand, glacial drift, shale, and sometimes sandstone. As a rule, there is considerable water in the sand.

No. 5 seam averages 50 inches in thickness. Although usually it is free of partings, sometimes there are lenses of pyrite in the seam. The overburden consists of soil and clay, in some places soft sandstone, and blue shale. The bottom is fireclay.

No. 6 seam at the mines described averages 6 feet in thickness. There are a number of partings of varying thickness in the seam, thickest of which is 4 inches. At some places there are irregular bands of pyrite in the seam. The overburden varies in character but as a rule consists of surface soil and clays, shale, limestone, and hard shale. There is a stratum of fireclay under the coal.

## MISSOURI AND SOUTHEASTERN KANSAS

### General Description of Area

The topography of the areas varies from rough in central and western Missouri to rolling and flat in southwestern Missouri and southeastern Kansas. At some places in central Missouri the coal outcrops on ridges, while in the western and southwestern parts of the State it may or may not apex at the surface.



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The Kansas City Southern, Wabash, Missouri Pacific, St. Louis & San Francisco, Atchison, Topeka & Santa Fe, and Joplin & Pittsburgh Railroads serve the mines described.

## General Geology

The coal beds mined are the Mulky, Bevier, Foster, or Mulberry in Missouri; Limestone lately correlated as the Bevier, Lightning Creek or Mineral, and Weir-Pittsburg in Kansas.

The Mulky seam averages 14 inches in thickness, is uniform in character, and is free of partings. The strata above the seam usually are hard black shale, limestone, and shale and surface clays. At places where the thickness of the overburden above the Mulky seam exceeds 40 feet, the Summit coal seam appears. This seam is not minable at the mines described. Below the Mulky seam is a stratum of hard gray shale.

The Bevier coal ranges in thickness from 40 to 42 inches at a Missouri property. There is a parting 6 to 8 inches thick, composed of hard, slabby shale and soft fireclay, usually 8 inches above the bottom of the seam. The coal seam at places contains thin lenses of pyrite. The stratum above the Bevier seam is hard gray shale 13 feet thick. The Mulky lies above this shale stratum. The bottom under the Bevier is usually fireclay 18 inches thick and under that limestone. At some places in this area both the Mulky and Bevier outcrop on the sides of deep valleys.

The Mulberry, or Foster, seam averages 30 inches in thickness in this area. There is a 1-inch parting containing pyrite at approximately the middle of the seam. The overlying strata are light-gray shale, hard shale (locally called soapstone), surface soil, and clay. The bottom is usually fireclay.

The Limestone seam has lately been correlated as the Bevier. This seam averages 17 inches in thickness, and is free from partings. Hardness is a characteristic of this coal. The strata above the coal consist of hard black shale, hard blue shale, surface soil, and clay. The underlying stratum is usually limestone.

The Mineral or Lightning Creek seam averages 22 to 24 inches in thickness. It is clean and free from partings. There are local dips, but as a rule it lies comparatively level, dipping to the northwest approximately 12 feet to the mile. In a few places there are clay veins of varying thickness that extend vertically through the seam; however, these are not as extensive as those found in the Weir-Pittsburg seam, which is 60 to 80 feet below the Mineral seam. The overlying strata comprise hard, black sandy shale (cap rock), blue shale, grayish brown sandy shale, sand, and surface clays. The bottom is fireclay.

The Weir-Pittsburg or Cherokee bed is 60 to 80 feet below the Mineral bed. It ranges from 30 to 38 inches in thickness and is free of partings, except that in some places there is a rash on top of the bed.



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One characteristic of this bed is the numerous clay veins or horsebacks that extend through it. Some Kansas operators estimate that 13 percent of the bed area is horseback. These clay veins are irregular in shape and extent. In estimating the recoverable tonnage of coal from a given area, consideration must be given to the probable area of horsebacks in the bed. The overlying strata vary in character but usually are hard sandy shale, sometimes shale and a thin stratum of sandstone, blue and black shale, shale, and a thin stratum of sandstone, surface soil, and clay. The bottom is black clay to fireclay.

## DESCRIPTIONS OF MINES

The mines described are situated as follows: Nos. 1, 2, 3, and 4 in Pennsylvania and Ohio; nos. 5, 6, 7, 8, 9, 10, 13, and 16 in Illinois and Indiana; and nos. 11, 12, 14, 15, 17, and 18 in Missouri and Kansas.

### Mine 1

The coal bed averages 52 inches thick and the overburden 38 feet. The usual maximum depth of overburden removed is 50 feet, although 70 feet has been removed in passing from one area of thinner cover to another. The overburden consists of shale with thin beds of limestone and sandstone, a thin coal seam, and soil and clay. The underlying stratum is limestone.

#### Method of Opening Property

Operations at this mine began by starting the opening cut approximately 80 feet inside the outcrop, where the overburden was 8 to 10 feet thick. This cut was made on top of the coal and followed the contour of the hill. This first cut was from 70 to 80 feet wide, and the excavated material was wasted on the surface toward the outcrop. The opening cut was continued to the limits of the property.

#### Drilling and Blasting Overburden

Figure 3 is a plan and section of a part of the workings of this mine.

When the overburden exceeds 25 feet in thickness it is drilled and shot. Drilling is done horizontally with a drill equipped with a crowfoot bit. Holes 6 inches in diameter are drilled to a depth of 50 to 80 feet, averaging 55 feet. These horizontal holes are spaced on 25-foot centers 6 to 8 feet above the top of the coal. The material drilled is a hard shale. The speed of drilling is approximately 1 foot per minute but varies somewhat with the formation. Two men operate the drill, and the average cost of drilling is 12 cents per foot.

The holes are charged with 4-½- by 16-inch, 40-percent ammonia-base, stick explosives. This charge is placed in the rear of the hole, tamped with clay stemming, and fired with an electric detonator. Approximately 9.6



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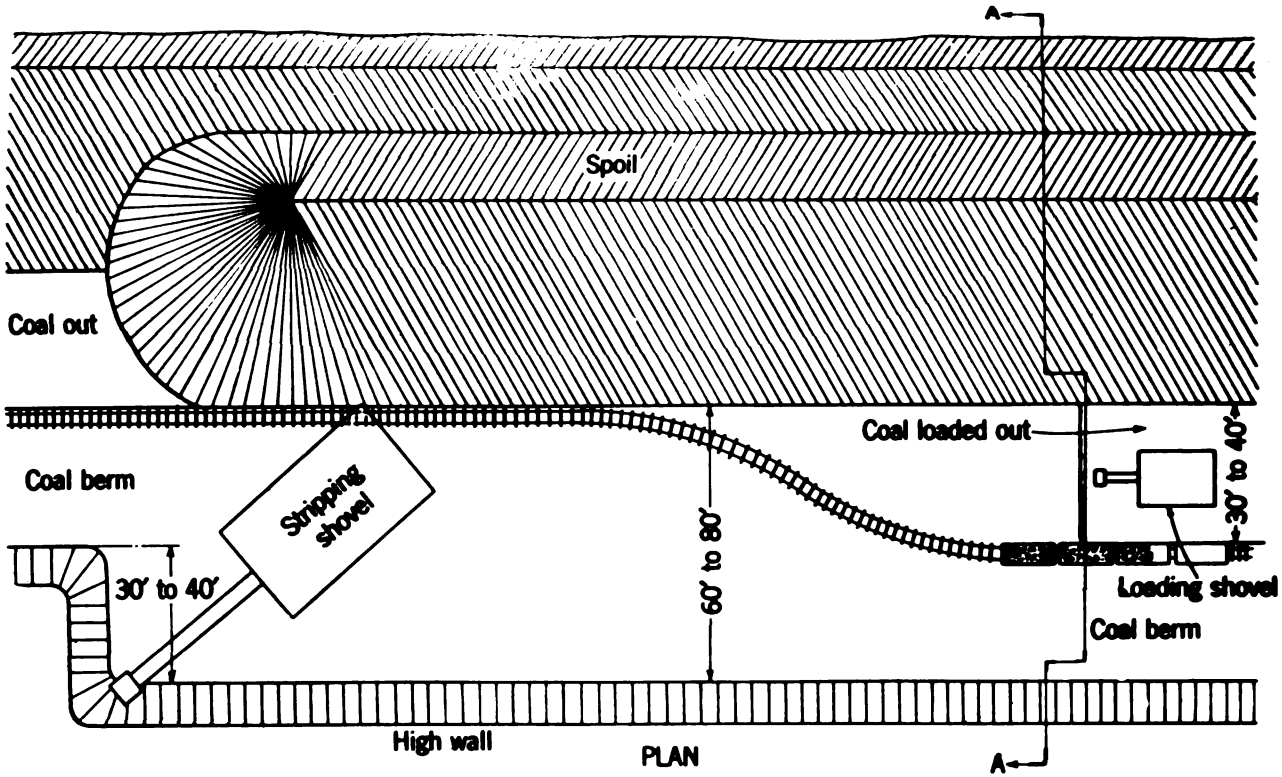


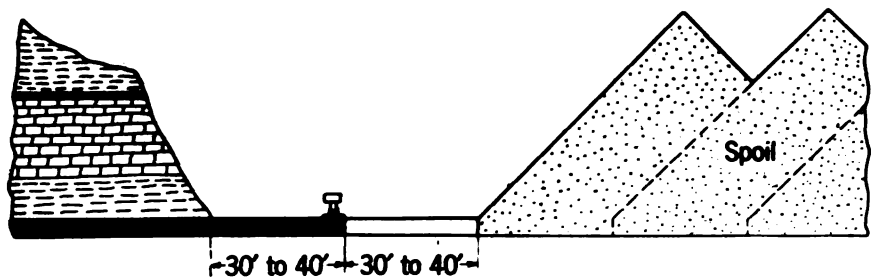


SECTION A-A

Figure 3.- Mining method at mine no. 1.

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cubic yards of overburden is broken per pound of explosive. Formerly the holes were charged as follows, beginning at the rear of the hole:

| | Feet |
|---|---|
| Explosive | 12 |
| Stemming | 15 |
| Explosive | 18 |
| Tamping | 30 |
| Hole | 75 |

This method of charging was found to be less effective than placing all the explosive together.

## Uncovering Coal

Stripping is being done in two areas on this property, but coal is loaded from each section alternately. Both stripping shovels are operated by steam and are of the full-revolving railroad type, moving on rails. The booms are 80 feet long and dipper sticks 56 feet, and the dippers have a capacity of 6 cubic yards.

After the initial or opening cut 70 to 80 feet wide has been made, the coal nearest the outcrop is removed for a width of 30 to 40 feet, or half the width of the cut. The stripping shovel then begins the second cut in the overburden. This cut is 30 to 40 feet wide, and the spoil is cast into the space from which the coal has been removed. The distance from the high wall to the spoil pile is 60 to 80 feet. The stripping shovel continues to dig until the dipper sticks have been extended to their effective limit. Then the shovel is moved 6 feet ahead, traveling on short sections of rail. The spoil is deposited in such a manner as to minimize the angle of swing of the shovel. Each operator has his idea as to the proper method to follow. The dipper is dumped so as to keep the foot of the spoil bank parallel to the cut.

The ideal cut is long and straight, but it is seldom possible to keep the cuts straight, owing to the irregular contour of the hills. The maximum space for dumping the spoil is obtained when the shovel is on an outside curve. Figure 2 shows the position of successive cuts in an irregular area. Each cut is shortened by increasing the radius, and finally one comparatively straight cut is made across the area.

One stripping shovel averaged 276 cubic yards per hour (actual digging time), and uncovered 31.7 tons of coal. The actual digging time of the shovel averaged 77 percent of the total time worked. The 23 percent lost time was due to major and minor repairs and delays.

After the overburden has been removed, the surface of the coal is cleaned with shovels and swept with steel brooms.



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## Coal Loading

Each section of the mine is equipped with a steam-powered loading shovel mounted on caterpillar trucks. The dippers are of the standard coal-loading type, each having a capacity of 1-½ cubic yards. One loading shovel is operated behind each stripping shovel.

The loading shovel operates on the bottom where the coal has been removed and loads the coal into cars. These cars run on a track on the coal berm or top of the coal. The coal is not blasted but is loaded from the solid face. An average of 85.5 tons per hour is loaded by each shovel.

## Haulage

Rail haulage is used, the track gage being 36 inches. The track is in the pit at the edge of the solid coal berm, which is usually in the center between the spoil pile and the high wall. (See fig. 3.) Wooden ties and various weights of rail are used. As the loading shovel advances in the first or box cut, the track is extended, and a 30- to 40-foot strip of coal is loaded out to the limit of the property. Then the track is shifted from the edge of the spoil bank to the center of the uncovered coal, a distance of 30 to 40 feet. Track shifting is done between the stripping shovel and the loading shovel with a crew consisting usually of seven men.

Side-dump-type cars of 4 tons capacity are used. These cars are hauled by 18-ton steam locomotives in trips of 10 cars each. Empty cars are placed alongside the loading shovel and when a trip is loaded the locomotive transports it to the tipple, a distance of approximately 2 miles. There are three trains in operation. A single track extends from the loading face to the tipple, with passing tracks at intervals to permit loaded and empty trips to pass.

## Drainage

The pits are self-draining. There are, however, several gasoline-driven centrifugal pumps on the property that can be used in an emergency.

## Preparation

The tipple is of wooden construction and is equipped with three loading tracks. The coal is dumped from the cars into a hopper and passes to shaking screens of the round-hole type. After sizing, it passes to picking tables and loading booms into railroad cars.

## Water Supply

Water for use in locomotives and shovels is obtained from a local water company and is pumped to water tanks for distribution to points where it is required.



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Summary

Shovel data (see tables 2 and 3).5/

| | |
|---|---|
| Average overburden removed per pound of explosive....cubic yards | 9.65 |
| Average stripped per hour digging.....do. | 276 |
| Average coal uncovered per hour digging.....tons | 31.7 |
| Ratio digging time to operating time.....percent | 77 |
| Average coal loaded per hour.....tons | 85.5 |
| Average daily production of coal.....do. | 740 |

5/ Tables 2 and 3 follow the description of individual mines (pp. 84-85) and give data on all stripping shovels, draglines, and loading shovels used in mines 1 to 18, inclusive.

Mine employees, based on production of 740 tons per working day per section

| Class | Number of men | Hours worked per day | Days worked per week | Total man-hours |
|---|---|---|---|---|
| Bank drilling and shooting | 2 | 7 | 5 | 70 |
| Stripping shovel: | | | | |
| Engineer 1 x 3 1/ | | | | |
| Craneman 1 x 3 | | | | |
| Oiler 1 x 3 | 24 | 7 | 6 | 1,008 |
| Fireman 1 x 3 | | | | |
| Groundmen 3 x 3 | | | | |
| Coal hauler 1 x 3 | | | | |
| Loading shovel: | | | | |
| Engineer 1 | | | | |
| Fireman 1 | 4 | 8.65 | 5 | 175 |
| Groundmen 2 | | | | |
| Coal cleaners | 3 | 8.65 | 5 | 130 |
| Trackmen | 5 | 7 | 5 | 175 |
| Locomotive engineers | 3 | 8.65 | 5 | 130 |
| Brakemen | 3 | 8.65 | 5 | 130 |
| Dumper | 1 | 7 | 5 | 35 |
| Tipplemen | 12 | 7 | 5 | 420 |
| Tipple foreman | 1 | 7 | 5 | 35 |
| Mechanics | 2 | 7 | 5 | 70 |
| Miscellaneous | 2 | 7 | 5 | 70 |
| Mine foreman | 1 | 8 | 5 | 40 |
| Superintendent | 1 | 8 | 6 | 48 |
| | 64 | | | 2,536 |

1/ 3 shifts.



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Recapitulation on weekly basis, production 3,700 tons

| Class | Number of man-shifts | Total man-hours | Tons per man per shift | Man-hour per ton |
|---|---|---|---|---|
| Bank drilling and shooting... | 10 | 70 | 370.0 | 0.019 |
| Stripping..... | 144 | 1008 | 25.7 | .273 |
| Loading..... | 35 | 305 | 105.7 | .082 |
| Haulage..... | 55 | 435 | 67.3 | .117 |
| Tipple..... | 70 | 490 | 52.8 | .132 |
| Miscellaneous..... | 20 | 140 | 185.0 | .038 |
| Supervision..... | 11 | 88 | 336.4 | .024 |
| Total..... | 345 | 2536 | 10.7 | .685 |

Note.- "Swing" crews are used to limit the work week to 35 hours per employee. Wage rates and working conditions are governed by contract between the operator and the United Shovel Operators and Helpers Association.

Mine 2

The topography of the property on which this mine is situated is rough. The coal averages 52 inches in thickness, an average section through coal and overburden being -

| | Feet | Inches |
|---|---|---|
| Soil and clay..... | ..... | |
| Sandstone..... | 6 | ..... |
| Black shale..... | 12 | ..... |
| Rooster coal..... | 1 | 8 |
| Limestone..... | 12 | ..... |
| Shale..... | 1 | ..... |
| Limestone..... | 2 | ..... |
| Shale..... | 5 | 6 |
| Coal..... | 4 | 4 |

The average thickness of the overburden is 45 feet, but at places a thickness of 68 feet has been removed.

Since the general plan of operation is similar to that described at mine 1, only those phases that differ will be described in detail.

Drilling and Blasting Overburden

Holes are drilled vertically from the top of the high wall. They are 20 to 30 feet from the edge of the bank, on 25-foot centers, and are drilled with a standard well-type rig powered with a gasoline engine. The diameter of the holes is 6 inches and they are drilled to within 5 to 8 feet



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of the top of the coal, the depth varying with the thickness of the overburden. Approximately 105 feet is drilled per 7-hour shift, and the cost averages 15 cents per foot of hole drilled.

The holes are usually chambered or sprung with 30 to 35 pounds of liquid oxygen explosive (LOX) and then charged with either LOX or 4-½- by 16-inch, 40-percent ammonia-base explosive. From 200 to 300 pounds of explosive is used for a 50-foot hole. Explosives are fired with electric detonators. Approximately 11.7 cubic yards of overburden is broken per pound of explosive.

## Uncovering Coal

A steam-operated stripping shovel is used to uncover the coal. It is of the full-revolving type, mounted on rails. The boom is 80 feet and the dipper stick 58 feet in length, and the capacity of the dipper is 6 cubic yards. This shovel operates in a pit 60 feet wide from high wall to spoil bank. Coal is removed for a width of 40 feet from the outside, leaving a 20-foot coal berm. The stripping shovel removes a cut 40 feet wide and deposits the waste material into the opening from which the coal has been removed. The method of operation is similar to that at mine 1.

The ratio of the actual digging time of the shovel to the total operating time is 63.3 percent, and it moves an average of 301 cubic yards per hour (actual digging time). The amount of coal uncovered per hour averages 28.9 tons.

Following the removal of the overburden, the surface of the coal seam is cleaned with a tractor-operated bulldozer and swept with steel brooms.

## Coal Loading

Loading is done with a steam-operated shovel mounted on caterpillars and equipped with a 1-¾-cubic yard dipper. The coal is taken from a cut 40 feet wide and loaded into cars placed on a track near the edge of the 20-foot berm, similar to figure 3. It is not necessary to shoot the coal. Approximately 66.7 tons of coal are loaded per hour.

## Haulage

Track is of mixed weights of rail ranging from 65 to 85 pounds and laid on wooden ties. Track gage is 36 inches. Motive power is supplied by three 18-ton steam locomotives, and each locomotive hauls two cars per trip. The haulage line is single-track, except for three passing tracks, and the average distance from the coal face to the tipple is 2-½ miles.

Cars are of the drop-bottom type and have a rated capacity of 25 tons. Side boards have been added to the cars and this capacity has been increased.



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## Drainage

A small amount of water accumulates in the pits and is gathered in sumps and discharged by 2-inch gasoline-driven centrifugal pumps.

## Preparation

The coal is dumped into a hopper at the tipple and passes to shaking screens for sizing; thence over picking tables and loading booms to railroad cars. The tipple is of wood and is equipped with three loading tracks.

## Summary

Shovel data (see tables 2 and 3).

| | |
|---|---|
| Average overburden per pound of explosive..... cubic yards | 11.75 |
| Average stripped per hour digging.....do. | 301 |
| Average coal uncovered per hour digging.....tons | 28.9 |
| Ratio of digging time to operating time.....percent | 63.3 |
| Average coal loaded per hour.....tons | 66.7 |
| Average daily production of coal.....do. | 625 |

Mine employees, based on production of 625 tons per working day

| Class | Number of men | Hours worked per day | Days worked per week | Total man-hours |
|---|---|---|---|---|
| Driller | 1 | 7 | 5 | 35 |
| Helper | 1 | 7 | 5 | 35 |
| Shooter | 1 | 7 | 5 | 35 |
| Stripping shovel: | | | | |
| Engineer 1 x 3 [1] | | | | |
| Craneman 1 x 3 | | | | |
| Fireman 1 x 3 | 21 | 7 | 5 | 735 |
| Oiler 1 x 3 | | | | |
| Groundmen 2 x 3 | | | | |
| Coal hauler 1 x 3 | | | | |
| Coal loader: | | | | |
| Engineer 1 | | | | |
| Fireman 1 | 3 | 9.3 | 5 | 140 |
| Groundman 1 | | | | |
| Coal cleaners | 3 | 9.3 | 5 | 140 |
| Locomotive engineers 3 | 6 | 9.3 | 5 | 280 |
| Locomotive brakemen 3 | | | | |
| Trackmen | 6 | 7 | 5 | 210 |
| Tipple | 11 | 7 | 5 | 385 |
| Mechanics | 2 | 7 | 5 | 70 |
| Miscellaneous | 3 | 7 | 5 | 105 |
| Superintendent | 1 | 8 | 6 | 48 |
| | 59 | | | 2,218 |

1/ 3 shifts.



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Recapitulation on weekly basis, production 3,125 tons

| Class | Number of man-shifts | Total man-hours | Tons per man per shift | Man-hour per ton |
|---|---|---|---|---|
| Bank drilling and shooting... | 15 | 105 | 208.3 | 0.034 |
| Stripping..... | 105 | 735 | 29.8 | .236 |
| Loading..... | 30 | 280 | 104.2 | .089 |
| Haulage..... | 60 | 490 | 52.1 | .157 |
| Tipple..... | 55 | 385 | 56.8 | .123 |
| Miscellaneous..... | 25 | 175 | 125.0 | .056 |
| Supervision..... | 6 | 48 | 520.8 | .015 |
| | 296 | 2218 | 10.5 | 0.710 |

Note.- "Swing" crews are used to limit the working week to 35 hours per employee. Wage rates and working conditions are governed by contract between the operator and the United Shovel Operators and Helpers Association.

## Mine 3

The coal outcrops on the side of hills, which are irregular. The seam ranges in thickness from 36 to 40 inches. A typical section through coal and overburden is as follows:

| | Feet | Inches |
|---|---|---|
| Surface clays and soil.. | .... | ..... |
| Rooster coal..... | .... | ..... |
| Limestone..... | 15 | ..... |
| Shale (soapstone)..... | 0 | 8 |
| Limestone..... | 1 | ..... |
| Shale (soapstone)..... | 5 | ..... |
| Coal..... | 3 | 2 |

The overburden averages 40 feet in thickness.

The property was opened in a manner similar to that at mine 1. The workings are on the hillsides and follow the contour of the hills. The coal is approximately 50 feet above the railroad tracks near the tipple.

### Drilling and Blasting Overburden

Vertical cracks are present in the thick limestone stratum, and the overburden is prepared for blasting by drilling holes both vertically and horizontally. Vertical holes are placed 30 feet from the edge of the bank and on 25-foot centers. They are 6 inches in diameter and are drilled to the rooster coal. The horizontal holes are drilled in the 8-inch stratum of shale (soapstone), which is immediately below the 15 feet of limestone. These holes are 6 inches in diameter, spaced approximately 20 feet apart, and drilled 65 to 75 feet deep. The vertical drill is the standard well-drill type. The horizontal drill is equipped with a clawlike cutting bit attached to an auger, which is made up in 10-foot sections.



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The drills are operated two 6-hour shifts per day, and the drilling cost averages 6 cents per foot.

The vertical holes are charged with approximately 2 pounds of explosives per foot depth of hole. The horizontal holes are charged with approximately 4.5 pounds of explosives per foot of vertical bank. Forty-percent ammonia-base explosives, in sticks 4-½ by 16 inches, are used, and the charges are exploded by two No. 6 electric detonators, placed one at each end of the charge. Approximately 10.4 cubic yards of overburden are broken per pound of explosive.

## Uncovering Coal

The overburden is removed with an electrically operated shovel, which is equipped with a 97-½ foot boom, 64-foot dipper stick, and a 16 cubic-yard dipper. The shovel is of the full-revolving type mounted on caterpillars and is self-propelling. Cuts are taken from the high wall, and the excavated material is deposited in the space from which the coal has been removed. Cuts are usually 30 feet wide, and the distance from high wall to spoil pile is 60 feet. This shovel advances 10 feet at each move. The average amount of overburden moved per hour, actual digging time, is 700 cubic yards, and 62 tons of coal is uncovered. Ratio of digging time to operating time is 81 percent.

The surface of the coal is cleaned with a tractor-operated road scraper and steel brooms.

## Coal Loading

The coal is loaded into trucks with an electrically operated coal-loading shovel equipped with a 3-cubic yard dipper. This shovel usually makes a cut 30 feet wide leaving a 30-foot coal berm next to the high wall on which the trucks operate. An average of 167 tons is loaded per hour. The coal is not shot.

## Haulage

Truck haulage is used at this mine. There are five truck-operated trailers, each having a capacity of 17 to 18 tons, which haul from the loading shovel to the tipple, an average distance of 1.5 miles. The main road is graded 30 feet wide. A width of 18 feet in the center of the road is surfaced with limestone, which has been crushed to 3 inches. A runway is graded from the surface into the pit, and the coal berm serves as the roadway to the loading shovel.

Average time required for loading one truck was 3.25 minutes, and the elapsed time for a round trip to the tipple was approximately 15 minutes.



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## Preparation

The tipple is equipped with round-hole shaking screens, loading booms, and picking tables. There are three loading tracks.

## Summary

Shovel data (see tables 2 and 3).

| | |
|---|---|
| Average overburden broken per pound of explosives.....cubic yards | 10.4 |
| Average stripped per hour digging.....do. | 701 |
| Average coal uncovered per hour digging.....tons | 62 |
| Ratio of digging time to operating time.....percent | 81 |
| Average coal loaded per hour.....tons | 167 |
| Average daily production of coal.....do. | 2,000 |
| Amount per kw.-hr., stripping.....cubic yards | 2.35 |
| Coal per kw.-hr., loading.....tons | 2.63 |
| Total power consumption per ton of coal.....kw.-hr. | 5.95 |

Mine employees, based on production of 2000 tons per working day

| Class | Number of men | Hours worked per day | Days worked per week | Total man-hours per week |
|---|---|---|---|---|
| Drillers..... | 4 | 6 | 5 | 120 |
| Helpers..... | 4 | 6 | 5 | 120 |
| Shooters..... | 2 | 6 | 5 | 60 |
| Stripping shovel: Runner 1 x 3[1], Oiler 1 x 3, Groundmen 3 x 3..... | 15 | 7.5 | 7 | 787.5 |
| Loading shovel: Runner 1 x 2[2], Groundmen 2 x 2..... | 6 | 6 | 5 | 180 |
| Coal cleaners 8 x 2..... | 16 | 6 | 5 | 480 |
| Truck drivers 5 x 2..... | 10 | 6 | 5 | 300 |
| Roadmen 5 x 2..... | 10 | 6 | 5 | 300 |
| Tipple 20 x 2..... | 40 | 6 | 5 | 1,200 |
| Mechanics..... | 2 | 7 | 5 | 70 |
| Miscellaneous 5 x 2..... | 10 | 6 | 5 | 300 |
| Foremen 3 x 2..... | 6 | 6 | 7 | 252 |
| Superintendent..... | 1 | 8 | 7 | 56 |
| | 126 | | | 4,225.5 |

1/ 3 shifts.
2/ 2 shifts.



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Recapitulation on weekly basis production 10,000 tons

| Class | Number of man-shifts | Total man-hours | Tons per man per shift | Man-hour per ton |
|---|---|---|---|---|
| Bank drilling and shooting... | 50 | 300 | 200 | 0.030 |
| Stripping..... | 105 | 787.5 | 95.2 | .079 |
| Loading..... | 110 | 660 | 91 | .066 |
| Haulage..... | 100 | 600 | 100 | .060 |
| Tipple..... | 200 | 1200 | 50 | .120 |
| Miscellaneous..... | 60 | 370 | 167 | .037 |
| Supervision..... | 49 | 308 | 204.1 | .031 |
| | 674 | 4225.5 | 14.9 | .423 |

Note.- "Swing" crew extra men are used in various operations to limit the work week to 35 hours on all units except the stripping shovel, which is according to the contract with the Union.

## Mine 4

The coal which averages 5 feet in thickness, outcrops on the sides of hills. An average section through coal and overburden is as follows:

| | Feet | Inches |
|---|---|---|
| Sand and clay..... | 8 | ..... |
| Laminated blue shale (tough)..... | 15 | ..... |
| Rooster coal..... | 2 | ..... |
| Limestone..... | 14 | ..... |
| Fireclay..... | 8 | ..... |
| Roof coal..... | 1 | ..... |
| Draw slate..... | 0 | 10 |
| Coal..... | 5 | ..... |

The mine consists of two sections and was opened near the outcrop, where the average thickness of the overburden was 10 to 12 feet. The first cut is usually 90 to 95 feet in width, and subsequent cuts are taken from the high wall, 45 feet in width. The irregular areas are mined by a method similar to that shown in figure 2.

### Drilling and Blasting Overburden

The thickness of the overburden averages 48 feet. The maximum thickness removed has been 72 feet, but it is usually limited to 50 feet. The bank is drilled vertically. Holes are placed 21 feet back from the edge of the high wall and spaced 26 to 30 feet apart. This arrangement loosens the overburden for a 45-foot cut. The diameter of the holes is 6 inches and they are drilled through the thick stratum of limestone into the fire clay above the roof coal. A standard well-type drilling rig is used. The cost of drilling averages 18 cents per foot of hole.



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Approximately 85 percent of the holes are chambered with one 4½- by 18-inch cartridge of LOX. The holes are then charged with 9 or 10 cartridges placed in the bottom of the hole. Clay stemming is then tamped into the hole until it reaches the top of the rooster coal. Then three or four cartridges of LOX are placed on top of the stemming and the rest of the hole is filled with clay stemming and tamped. This method of preparation places one charge of explosive at the limestone stratum and another in the tough laminated shale. The detonating charge consists of a stick of 40-percent gelatin dynamite, which is exploded electrically. There are two detonators for each hole, one in the top and the other in the bottom charge. The character of the overburden is different in the two sections, but an average of 16.15 cubic yards is broken per pound of explosive.

## Uncovering Coal

Each section of the mine is equipped with a steam-operated, full-revolving-type shovel mounted on rails. The shovels are equipped with 90-foot booms, 54-foot dipper sticks, and dippers with a capacity of 6 cubic yards. Stripping is continuous at both operations, but coal is loaded alternately from each. The distance from high wall to spoil pile is usually 90 feet. Cuts from the high wall are approximately 45 feet, or equal to the width of the coal cut. The excavated material is placed on the area from which the coal has been removed. Shovels are advanced 6 to 8 feet per move. Approximately 5,000 cubic yards is moved in 21 hours by each unit. There is a 1-inch layer of bone on top of the coal seam and a tractor-operated bulldozer is used to clean the surface of the coal.

## Coal Loading

It is necessary to shoot the coal at some places, where there are local dips and the coal is harder than where it is level. The coal is shot with either black or pellet powder, except where it is wet, and then a half stick of dynamite is used for each hole.

Each section is equipped with a steam-operated loading shovel. The dippers are of the coal-loading type and have a capacity of 1½ cubic yards. These shovels remove the coal from a cut 45 feet wide on the side nearest the outcrop or spoil bank. The coal is loaded into cars placed near the edge of the coal berm.

The position of loading shovel and track is similar to that shown in figure 3.

The loading shovel operates 11 hours per day and has a capacity of 200 tons an hour.

## Haulage

Rail haulage with a track gage of 36 inches is used. The track is constructed with 60-pound rail placed on wooden ties. The maximum grade against the loads is 3 percent and 4 percent in favor of the loads.



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Motive power is furnished by two, 30-ton, geared steam locomotives. Each of these locomotives hauls five 30-ton-capacity drop-bottom cars per trip. The capacity of the cars was increased from 25 to 30 tons by the addition of 10-inch and 18-inch side boards, the 18-inches being on the far side from the loading shovel. An 18-ton rod or standard-type locomotive is used as a helper at two places in the line where the grades are heaviest. The length of the line from coal face to tipple is approximately 2½ miles, and it is single track, except for passing tracks. The average loading time is 25 minutes per trip.

## Drainage

It is necessary to pump water from the pits following heavy rains. The water is ditched to sumps and discharged by small gasoline-driven pumps.

## Preparation

Coal is dumped from cars into a 200-ton bin at the tipple. From the bin it is fed by double feeders into a 5-foot pan conveyor, which passes the coal to either a crusher or shaking screens. The screens are of the round-hole type, and the coal is sized according to demand. The tipple is equipped with three loading tracks, picking tables, and loading booms. The tipple machinery is operated by alternating current purchased from a public utility.

## Water Supply

Water for shovels and locomotives is supplied from deep wells and a spring. When running full time, 70,000 to 75,000 gallons are used per day.

## Summary

Shovel data (see tables 2 and 3).

| | |
|---|---|
| Average overburden per pound of explosive.....cubic yards | 16.15 |
| Average stripped per hour digging.....do. | 238 |
| Average coal uncovered per hour digging.....tons | 26 |
| Ratio of digging time to operating time.....percent | 82 |
| Average coal loaded per hour.....tons | 145 |
| Average daily production of coal.....do. | 1600 |



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Mine employees, based on production of 1,600 tons per working day

| Class | Number of men | Hours worked per day | Days worked per week | Total man-hours per week |
|---|---|---|---|---|
| Drillers | 4 | 7 | 5 | 140 |
| Helpers | 4 | 7 | 5 | 140 |
| Shooters | 4 | 7 | 5 | 140 |
| Stripping shovels, two: 2 engineers x 3 [1]; 2 cranemen x 3; 2 firemen x 3; 2 oilers x 3; 2 x 4 groundmen x 3 | 48 | 7 | 7 | 2,352 |
| Loading shovel: 1 engineer x 2 [2]; 1 fireman x 2; 2 pitmen x 2 | 8 | 5.5 | 5 | 220 |
| Coal cleaners 2 x 8 | 16 | 5.5 | 5 | 440 |
| Locomotive engineers 1 x 2 | 2 | 5.5 | 5 | 55 |
| Locomotive brakemen 1 x 2 | 2 | 5.5 | 5 | 55 |
| Trackmen | 3 | 7 | 5 | 105 |
| Tipple 2 x 14 | 28 | 5 | 5 | 700 |
| Waste disposal 2 x 2 | 4 | 5 | 5 | 100 |
| Mechanics | 3 | 7 | 5 | 105 |
| Miscellaneous | 10 | 7 | 5 | 350 |
| Superintendent | 1 | 8 | 7 | 56 |
| | 137 | | | 4,958 |

1/ 3 shifts.
2/ 2 shifts.

Recapitulation on weekly basis, production 8,000 tons

| Class | Number of man-shifts | Total man-hours | Tons per man per shift | Man-hour per ton |
|---|---|---|---|---|
| Bank drilling and shooting | 60 | 420 | 133 | 0.053 |
| Stripping | 336 | 2,352 | 23.8 | .293 |
| Loading | 120 | 660 | 6.7 | .082 |
| Haulage | 35 | 215 | 22.9 | .027 |
| Tipple | 160 | 800 | 50 | .100 |
| Miscellaneous | 65 | 455 | 12.3 | .057 |
| Supervision | 7 | 56 | 1143 | .007 |
| | 783 | 4,958 | 10.2 | 0.619 |

Note.- Extra men are available for different classes of work to adhere to the terms of the contract between the operator and the union.



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## Mine 5

The surface of the land at this property is practically level. The outcrop of the coal is covered and it is located by drilling, usually with hand drills. The coal ranges from 33 to 36 inches in thickness. There is one parting, with a maximum thickness of 2 inches, approximately 9 inches from the top of the seam. The overburden varies in character and thickness, but usually consists of sandy clay, sandstone, and shale. At places the sandstone is 20 feet thick. When this occurs, the overburden is drilled vertically; but where the sandstone is thinner, the bank is drilled horizontally.

### Drilling and Blasting Overburden

Figure 4-B, shows the system of vertical drilling used. Holes, which are 6 inches in diameter, are drilled on 25-foot centers and to within 18 inches of the top of the coal. They are drilled with a standard well-type rig. There are two drilling rigs, each operated by two men. As a rule, four holes 36 feet deep are drilled in a shift by each crew. Each hole is charged with 100 pounds of 30 percent explosive and is fired with electric detonators. Approximately 7.5 cubic yards is broken per pound of explosive.

When horizontal holes are used, they are also spaced 25 feet apart and are 4 inches in diameter and 35 feet in depth. The holes are placed 18 inches above the top of the coal. Two men can drill and shoot three holes in a shift. These holes are charged as follows: 50 pounds of 40-percent, 2½- by 8-inch gelatin dynamite, 4 feet of clay stemming, 50 pounds of 40-percent, 2½- by 8-inch gelatin dynamite, and the remainder of the hole tamped with clay stemming. The holes are fired with electric detonators. Approximately 9.6 cubic yards are broken per pound of explosive.

### Uncovering Coal

The coal area was opened with a box cut (fig. 4,A) averaging 30 feet in depth. A borrow pit was first made outside the crop with a dragline excavator. The edge of the borrow pit, which is 80 feet wide and 15 feet deep, is 35 feet from the side of the box cut, which is 65 feet wide. (Fig. 4.) The excavated material from the box cut is dumped into the borrow pit, and the slope of the spoil averages 1½ to 1. Successive cuts from the high wall are usually 40 to 45 feet wide, and the distance from high wall to spoil bank averages 70 feet.

The stripping shovel, which is electrically operated, has a 105-boom, 72-foot dipper stick, and 30-cubic-yard-capacity dipper. The shovel is usually advanced 8 feet with each move. This shovel has not been in operation long enough to give a fair estimate of yardage excavated per hour.

The surface of the coal is cleaned with a bulldozer, shovels, and wire brooms.



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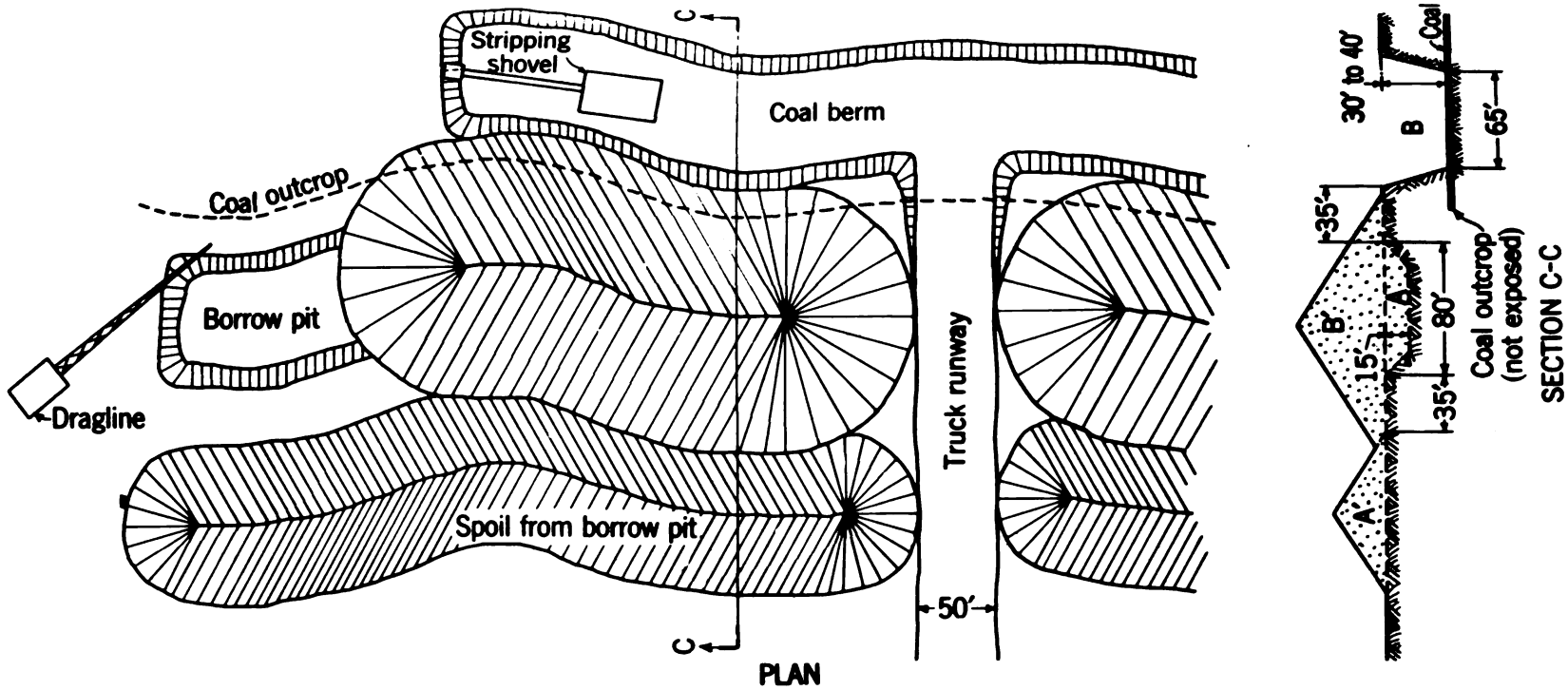
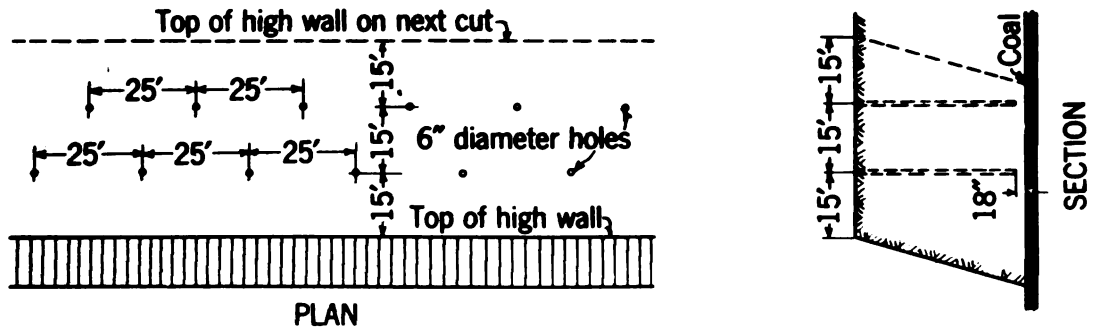



A. Borrow pit method of opening box cut at mine no. 5




B. Spacing of vertical holes in drilling overburden at mine no. 5.

Figure 4.

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## Coal Loading

The coal is shot before loading. Holes are drilled on 10- to 12-foot centers with an electric coal drill and are charged with 1/2 to 1 stick of 40-percent gelatin dynamite and fired with electric detonators.

A coal-shearing machine cuts parallel to the length of the pit, usually 30 feet from the high wall. This makes a straight wall for the loading shovel to work against, and also an even berm line, an advantage with truck haulage.

The coal is loaded from a cut 40 feet wide with an electrically operated loading shovel having a 3-¾-cubic-yard dipper. The coal is loaded into trucks, which operate on the 30-foot coal berm. Approximately 257 tons of coal is loaded per hour.

## Haulage

Truck haulage is used from the coal face to the tipple. Five truck-drawn trailers having a capacity of 16 tons each are in use. A main haulage road is constructed outside the opening cut, and roadways are made into the pit from the main road at varying intervals averaging, about 700 feet. The main road is graded 50 feet wide. Sandstone from the overburden is crushed to 2 inches and used for the subbase. Cinders are used as a top dressing.

## Drainage

Water that accumulates in the pit is pumped to the surface with electrically operated pumps. These are mounted on skids and can be moved easily from place to place.

## Preparation

The coal is dumped from the trailers into a hopper and is conveyed to shaking screens in the tipple. The coal is sized according to demand. The tipple is constructed of steel, is equipped with picking tables and loading booms, and has five loading tracks.

## Power

Electric power is purchased from a public utility company, and comes in at 33,000-volt, 3-phase, 60-cycle alternating current. It is stepped down by transformers to 4,000 volts for use on the stripping shovel and to 2,300 volts on the loading shovel. Other equipment is supplied with 440-volt alternating current.



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Summary

Shovel data (see tables 2 and 3).

| | |
|---|---|
| Average overburden per pound of explosive.....cubic yards | 9.6 |
| Average stripped per hour.....do. | 1,000 |
| Ratio of digging time to working time.....percent | 70 |
| Average clean coal loaded per hour.....tons | 257 |
| Power consumption per ton of coal.....kw.-hr. | 5.2 |
| Average daily production of clean coal.....tons | 1,800 |

Mine employees, based on production of 1,800 tons per working day

| Class | Number of men | Hours worked per day | Days worked per week | Total man-hours per week |
|---|---|---|---|---|
| Drillers<br>Helpers.....<br>Shooters | 12 | 7 | 6 | 504 |
| Stripping shovel:<br>Engineer 1 x 3 1/<br>Oiler 1 x 3.....<br>Groundmen 1 x 3 | 9 | 8 | 6 | 432 |
| Loading shovel:<br>Operator<br>Oiler.....<br>Groundman | 3 | 7 | 6 | 126 |
| Cleaning and shooting coal... | 14 | 7 | 6 | 588 |
| Truck operators..... | 5 | 7 | 6 | 210 |
| Truck maintenance..... | 3 | 7 | 6 | 126 |
| Road maintenance..... | 6 | 7 | 6 | 252 |
| Tipple..... | 32 | 7 | 6 | 1,344 |
| Mechanics..... | 5 | 7 | 6 | 210 |
| Electricians..... | 5 | 7 | 6 | 210 |
| Miscellaneous pit..... | 1 | 7 | 6 | 42 |
| Other miscellaneous..... | 1 | 8 | 6 | 48 |
| Clerks..... | 3 | 8 | 6 | 144 |
| Mine foreman..... | 1 | 8 | 6 | 48 |
| Enginemen..... | 2 | 8 | 6 | 96 |
| Superintendent..... | 1 | 8 | 6 | 48 |
| | 103 | | | 4,428 |

1/ 3 shifts.



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Recapitulation on weekly basis, production 10,800 tons

| Class | Number of man-shifts | Total man-hours | Tons per man per shift | Man-hour per ton |
|---|---|---|---|---|
| Bank drilling and shooting... | 72 | 504 | 150 | 0.047 |
| Stripping..... | 54 | 432 | 200 | .040 |
| Loading..... | 102 | 714 | 105.9 | .066 |
| Haulage..... | 84 | 588 | 128.6 | .054 |
| Tipple..... | 192 | 1,344 | 56.3 | .125 |
| Miscellaneous..... | 102 | 750 | 105.9 | .069 |
| Supervision..... | 12 | 96 | 900 | .009 |
| | 618 | 4,428 | 17.5 | .410 |

Note.- Wage rates and working conditions are governed by contract between operator and United Mine Workers of America.

## Mine 6

The topography of this property is rolling. The coal, which averages 4 feet 5 inches in thickness, outcrops at places in valleys but for the greater part lies buried. The outline of the coal body is irregular, and it is located by drilling with hand drills with holes usually on 100-foot centers.

As a rule the coal dips 2 to 3 percent, but greater dips occur locally, and differences of elevation of the seam as found by drilling are more important than its thickness.

The overburden varies in character and thickness at different places in the mine. A section at one place was as follows:

| | Feet | Inches |
|---|---|---|
| Surface soil..... | 8 | 8 |
| Sandstone..... | 15 | 5 |
| Black, hard shale..... | .... | 3 |
| Limestone..... | 2 | 6 |
| Gray shale..... | 1 | 10 |
| Black, blocky hard shale (steel band)..... | .... | 6 |
| Black, hard shale..... | 2 | 3 |
| Coal..... | 4 | 5 |
| Fireclay..... | .... | 3 |

This mine consists of 2 sections.

### Drilling and Blasting Overburden

Drills of the horizontal type are used, one in each section of the mine. Holes 6 inches diameter and 50 feet deep are spaced on 20-foot centers. They are drilled approximately 2 feet above coal in the stratum of black shale. If the thickness of the sandstone and limestone is excessive, the drills are



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mounted on a truck and another row of holes is drilled. These holes are started in the gray shale above the steel band and drilled at an angle of 45°. The drills are electrically driven and are operated by two men each on three shifts. Each crew drills approximately six holes per shift.

The holes are not chambered but are charged with LOX. The cartridges are 4½ inches in diameter by 18 inches in length, and the effective weight is approximately 12 pounds. The amount of explosive varies according to the character of overburden but averages 134 cubic yards per cartridge of LOX. The primer is usually a stick of 40-percent gelatin dynamite exploded with an electric detonator. In the horizontal holes the charge is divided, the two parts being separated by approximately 10 feet of stemming, while the 45° holes have the entire charge at the end of the hole. The shooting crew consists of nine men and a foreman, who do all the blasting in both pits.

## Uncovering Coal

The stripping equipment at each section is as follows:

Section 1 - Electrically operated shovel equipped with an 85-foot boom, 60-foot dipper stick, and 22-cubic-yard dipper.
2 - Electrically operated shovel equipped with a 95-foot boom, 64-foot dipper stick, and 17-cubic-yard dipper.

The width of cuts taken from the high wall is usually 50 feet, and the distance from high wall to spoil bank is 65 to 70 feet. The working berm as a rule is 20 feet wide. The spoil pile stands on a 1.37 to 1 slope, and the high wall is about 70° from the horizontal. The average thickness of the overburden is 40 feet. Under present physical conditions the 22-cubic-yard shovel will remove about 16,000 cubic yards in three 8-hour shifts, and the 17-cubic-yard machine will handle approximately 12,000 cubic yards in the same period.

The surface of the coal is cleaned with a bulldozer, hand shovels, and wire brushes.

## Coal Loading

The loading practice is the same in both sections. As a rule, the coal is drilled with auger-type drills and shot with pellet powder. The loading shovels are electrically operated and have a 3½- and 5-cubic yard capacity dipper, respectively. The smaller loader follows the smaller stripping shovel. The loading shovels remove the coal from a cut 45 feet wide and the coal is loaded into trucks that operate on the 20-foot coal berm. The trailers of the trucks are of the drop-bottom type and have a rated capacity of 20 tons. This capacity has been increased to 22 tons by the addition of side boards. The loading time is approximately 2 minutes.

The loaders operate 10 hours per day - one 7-hour shift and about 3 hours at night. The coal loaded at night is stored in the empty cars in order that the tipple may have a supply of coal when it starts work the following day.



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The large loading shovel loads an average of 2,200 tons a day and the smaller one, 1,800 tons.

## Haulage

A combination of truck and rail haulage is used. Trucks and trailers carry the coal from the loading shovels to a central dumping station at the end of the rail haul, and from here the coal is passed to cars and transported in trains to the tipple.

There are eight 20-ton truck units that serve both pits. At present there is approximately $\frac{3}{4}$ mile of main road outside the present working area and $\frac{3}{4}$ mile on the coal. Lateral runways extend from the main road through the spoil pile onto the coal berm. The main road, which is 30 feet wide, is graded and drained. The subbase consists of waste from the tipple and is about 1 foot thick. Finer waste is placed on top of the large gob to a thickness of 1 foot. The road is then surfaced with 6 inches of cinders. The roads are maintained by a crew of four men and a tractor road maintainer and are sprinkled regularly with water. The maximum grade is 5 percent.

Trucks dump into a hopper at the central dumping station. The coal is then transported by a pan-type conveyor to the main hopper over the railroad tracks where it is discharged into cars by four reciprocating feeders, two for each track.

The double-track railroad extends from dumping station to tipple, a distance of approximately $4\frac{1}{2}$ miles. Tracks are 3-foot gage on 12-foot centers and are constructed with 60- and 70-pound rails on wooden ties.

Motive power is supplied by five rod-type steam locomotives. Cars are of the side-dump type and have a capacity of approximatly 5 tons. Trips consist of 24 cars (120 tons), and an average of one round trip is made per hour. This rail haulage is to be electrified.

## Drainage

Water that accumulates in the pits is gathered into sumps and discharged by electric pumps into surface ditches or wooden flumes and carried to natural drainage courses.

## Preparation

The tipple, which is equipped with shaking and vibrating screens, picking tables, and loading booms, has a capacity of 700 tons per hour.

## Power

Alternating current is purchased from a public utility company. It is 33,000-volt, 3-phase, 60-cycle current that is stepped down by transformers to 4,400, 2,300, and 440 volts for use on various equipment.



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## LOX Plant

Liquid-oxygen explosive is manufactured on the property. The plant has a capacity of 7,000 pounds of liquid oxygen per 24 hours.

### Summary

Shovel data (see tables 2 and 3).

| | |
|---|---|
| Average overburden per pound of explosive.....cubic yards | 5.0 |
| Average stripped per hour.....do. | 726 |
| Average coal uncovered per hour.....tons | 94 |
| Ratio of digging time to operating time.....percent | 77.6 |
| Average coal loaded per hour.....tons | 695 |
| Average power consumption per ton.....kw.-hr. | 6.1 |
| Average daily production.....tons | 4,000 |

Mine employees, based on production of 4,000 tons per working day (two units)

| Class | Number of men | Hours worked per day | Days worked per week | Total man-hours per week |
|---|---|---|---|---|
| Drillers 1 x 2[1] x 3[2] Helpers 1 x 2 x 3 | 12 | 7 | 5 | 420 |
| Shooters | 10 | 7 | 5 | 350 |
| Stripping shovels: Operator 1 x 2[1] x 3[2] Oiler 1 x 2 x 3 Groundmen 3 x 2 x 3 | 30 | 8 | 6 | 1,440 |
| Loading shovels: | | | | |
| Operator | 1 | 8 | 5 | 40 |
| Pitmen | 2 | 7 | 5 | 70 |
| Operator | 1 | 11 | 5 | 55 |
| Pitmen | 2 | 10 | 5 | 100 |
| Coal cleaning | 4 | 7 | 5 | 140 |
| Locomotive crews | 10 | 7 | 5 | 350 |
| | 2 | 3 | 5 | 30 |
| Truck operators | 8 | 7.5 | 5 | 300 |
| | 3 | 3.5 | 5 | 53 |
| Dumping station | 4 | 7 | 5 | 140 |
| | 2 | 3 | 5 | 30 |
| Roadmen | 5 | 7 | 5 | 175 |
| Trackmen | 10 | 7 | 5 | 350 |
| Tipple | 40 | 7 | 5 | 1,400 |
| Electricians | 5 | 7 | 5 | 175 |
| Machine shop | 10 | 7 | 5 | 350 |
| Miscellaneous: | | | | |
| Pumpers | 5 | 7 | 5 | 175 |
| Car repairers | 5 | 7 | 5 | 175 |
| Repairmen, etc. | 20 | 7 | 5 | 700 |
| Teamsters | 3 | 7 | 5 | 105 |
| Monthly men | 8 | 8 | 6 | 384 |
| | 202 | | | 7,507 |

1/ 2 machines.
2/ 3 shifts.



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Recapitulation on weekly basis, production 20,000 tons

| Class | Number of man-shifts | Total man-hours | Tons per man per shift | Man-hours per ton |
|---|---|---|---|---|
| Rank drilling and shooting... | 110 | 770 | 181.8 | 0.038 |
| Stripping..... | 180 | 1,440 | 111.1 | .072 |
| Loading..... | 50 | 405 | 400.0 | .020 |
| Haulage..... | 220 | 1,428 | 90.9 | .071 |
| Tipple..... | 200 | 1,400 | 100.0 | .070 |
| Miscellaneous..... | 264 | 1,872 | 75.8 | .094 |
| Supervision..... | 24 | 192 | 83.3 | .010 |
| | 1,048 | 7,507 | 19.1 | .375 |

## Mine 7

The coal averages 4 feet in thickness. The overburden varies in thickness and character but at present averages 26 feet. It consists of surface soil and clay, yellow sandstone, and hard gray shale. The bottom is sandstone to fireclay.

### Drilling and Blasting Overburden

The overburden is drilled horizontally with an auger-type drill driven by an electric motor. Holes, which are 6 inches in diameter, are spaced on 20-foot centers and drilled 40 feet deep. They are placed 2½ to 4 feet above the coal and drilled in the gray shale. The drill is operated by two men, and from 6 to 8 holes are drilled per shift. Two shifts are worked, depending upon the character and thickness of the overburden.

The holes are chambered with 4 to 6 pounds of 40 percent dynamite. They are then charged with 40 to 60 percent dynamite. Where the overburden is not hard rock, FFF black powder is used. The thickness of the sandstone governs the amount of explosive used. This ranges from 100 to 225 pounds per hole. The charge is fired with an electric detonator. The shooting crew consists of one man.

### Uncovering Coal

The coal is uncovered with an electric-type shovel equipped with a 95-foot boom, 64-foot dipper stick, and dipper of 12 cubic yards capacity. Cuts approximately 45 feet wide are made from the high wall. The working berm is usually 35 feet wide. The width of the pit from high wall to spoil bank varies with the thickness of the overburden but averages about 85 feet. The shovel advances approximately 9 feet per move, and actual digging time averages 82 percent of the total working time. An average of 4,300 cubic yards of overburden is removed per 8-hour shift.

The surface of the coal is cleaned with a tractor-operated bulldozer.



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## Coal Loading

The width of coal cut averages 50 feet. The coal is loaded with an electrically operated loading shovel equipped with a coal loading dipper of $3\frac{1}{2}$-cubic-yard capacity. The coal is not shot before loading. It is loaded into cars placed adjacent to the loading shovel. As a rule, the loading shovel operates a full day shift and an additional 4 hours at night.

## Haulage

Rail haulage is used from the loading shovel to the tipple. Track is standard gage (4 feet $8\frac{1}{2}$ inches) and is constructed of 70-pound rail on wooden ties. Cars are of the drop-bottom type and have a capacity of 40 tons. They are hauled by 42-ton geared locomotives in trips of five cars each. Three haulage units are in use on the day shift and two units are used at night. Passing tracks are located approximately 1,000 feet apart.

The track is usually on the coal, an average distance of 50 feet from the spoil pile. Following the removal of the coal, the track is shifted the width of the next coal cut, or 50 feet, by a tractor operated by a track crew. The track is lined and leveled by crews that work at night.

## Drainage

Water that accumulates in the pit is carried by ditches to sumps and discharged by electric pumps to the surface.

## Preparation

The coal is sized in the tipple, which is equipped with shaking screens. The minus 4-inch coal is washed. The larger sizes pass over picking tables and loading booms to railroad cars.

## Power

All power used at the mine is purchased. Alternating current is supplied at 4,000 volts, 3 phase, 60 cycle, and is stepped down by transformers for use on shovels and other equipment around the mine.

## Summary

Shovel data (see tables 2 and 3).

| | |
|---|---|
| Average overburden per pound of explosive.....cubic yards | 13 |
| Average stripped per hour.....do. | 537 |
| Average coal uncovered per hour.....tons | 77 |
| Ratio of digging time to operating time.....percent | 82 |
| Average coal loaded per hour.....tons | 380 |
| Power consumption per ton of coal.....kw.-hr. | 5 |
| Average daily production clean coal.....tons | 2,200 |



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Mine employees, based on production of 2,200 tons per working day

| Class | Number of men | Hours worked per day | Days worked per week | Total man-hours per week |
|---|---|---|---|---|
| Drillers 1 x 2[1] | 2 | 7 | 5 | 70 |
| Helpers 1 x 2 | 2 | 7 | 5 | 70 |
| Shooters | 1 | 7 | 5 | 35 |
| Stripping shovel: | | | | |
| Engineers 2 x 3[2] | 9 | 8 | 6 | 432 |
| Groundmen 1 x 3 | | | | |
| Loading shovel: | | | | |
| Operators | 2 | 12 | 5 | 120 |
| Cleaning coal | 1 | 7 | 5 | 35 |
| Locomotive crews: | | | | |
| 3 x 2 | 6 | 7 | 5 | 210 |
| 2 x 2 | 4 | 4 | 5 | 80 |
| Trackmen | 23 | 7 | 5 | 805 |
| Tipple and washer | 25 | 7 | 5 | 875 |
| Miscellaneous | 12 | 7 | 5 | 420 |
| Monthly | 6 | 8 | 6 | 288 |
| Supervision | 6 | 8 | 6 | 288 |
| | 99 | | | 3,728 |

1/ 2 shifts.
2/ 3 shifts.

Recapitulation on weekly basis, production 11,000 tons

| Class | Number of man-shifts | Total man-hours | Tons per man per shift | Man-hours per ton |
|---|---|---|---|---|
| Bank drilling and shooting | 25 | 175 | 440 | 0.016 |
| Stripping | 54 | 432 | 203.7 | .039 |
| Loading | 15 | 155 | 733.3 | .014 |
| Haulage | 165 | 1,095 | 66.7 | .100 |
| Tipple | 125 | 875 | 88 | .080 |
| Miscellaneous | 96 | 708 | 114.5 | .064 |
| Supervision | 36 | 283 | 305.5 | .026 |
| | 516 | 3,728 | 21.3 | .339 |

## Mine S

This mine is situated in an area having a comparatively flat surface. The coal averages 3 feet in thickness and is free from partings, but it does have thin vertical joints filled with calcite. The overburden varies in thickness and character. In some places it consists of soil, 5 to 20 feet of yellowish sand, which is very wet, 0 to 30 feet of glacial drift (clay, boulders, and gravel), and 0 to 40 feet of shale, called soapstone locally. This shale sometimes varies from a smooth talclike structure to coarse sandstone. A detailed section in one part of the mine is as follows:



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| | Feet | Inches |
|---|---|---|
| Surface loam | 1 | 6 |
| Yellow sand | 2 | ..... |
| Clay | 3 | ..... |
| Sandstone | 8 | ..... |
| Sandy shale | 3 | 6 |
| Coal | 3 | ..... |
| Fireclay | .... | ..... |

The coal does not outcrop at the surface, and the position is determined by drilling. It dips slightly to the southwest, following the regional dip. At places there are extreme local dips of approximately 10 percent.

## Drilling and Blasting Overburden

When sandstone is present, the overburden is drilled with a horizontal drill. Holes are placed in the shale under the sandstone and are spaced 30 to 50 feet apart, depending on the thickness and character of the sandstone. The holes are 6 inches in diameter and drilled 50 feet deep. The drill is electrically driven and is operated by two men.

The holes are not chambered and are charged with 4- by 16-inch 30-percent gelatin dynamite. Electric detonators are used to fire the charge. The amount of explosive used is variable, due to the irregular character of the overburden.

## Uncovering Coal

This mine consists of four sections and the stripping units in each are as follows:

Section

1. Electrically operated shovel equipped with a 102-foot 6-inch boom, 69-foot 2-inch stick, and 32-cubic-yard dipper.
2. Electrically operated shovel equipped with a 90-foot boom, 68-foot stick, and 17-cubic-yard dipper.
   Electrically operated dragline equipped with a 170-foot boom and 14-cubic-yard bucket.
3. Electrically operated shovel equipped with 90-foot boom, 68-foot stick, and 17-cubic-yard dipper.
   Electrically operated dragline equipped with a 170-foot boom and 14-cubic-yard bucket.
4. Electrically operated dragline equipped with a 150-foot boom and 9-cubic-yard bucket.

The opening box cut, 80 to 90 feet wide, is usually made by a drag line. Since this machine has a long boom, it can cast the waste a sufficient distance to prevent it from rolling back into the cut. The thickness of the overburden may be 20 to 35 feet. The spoil is wasted on



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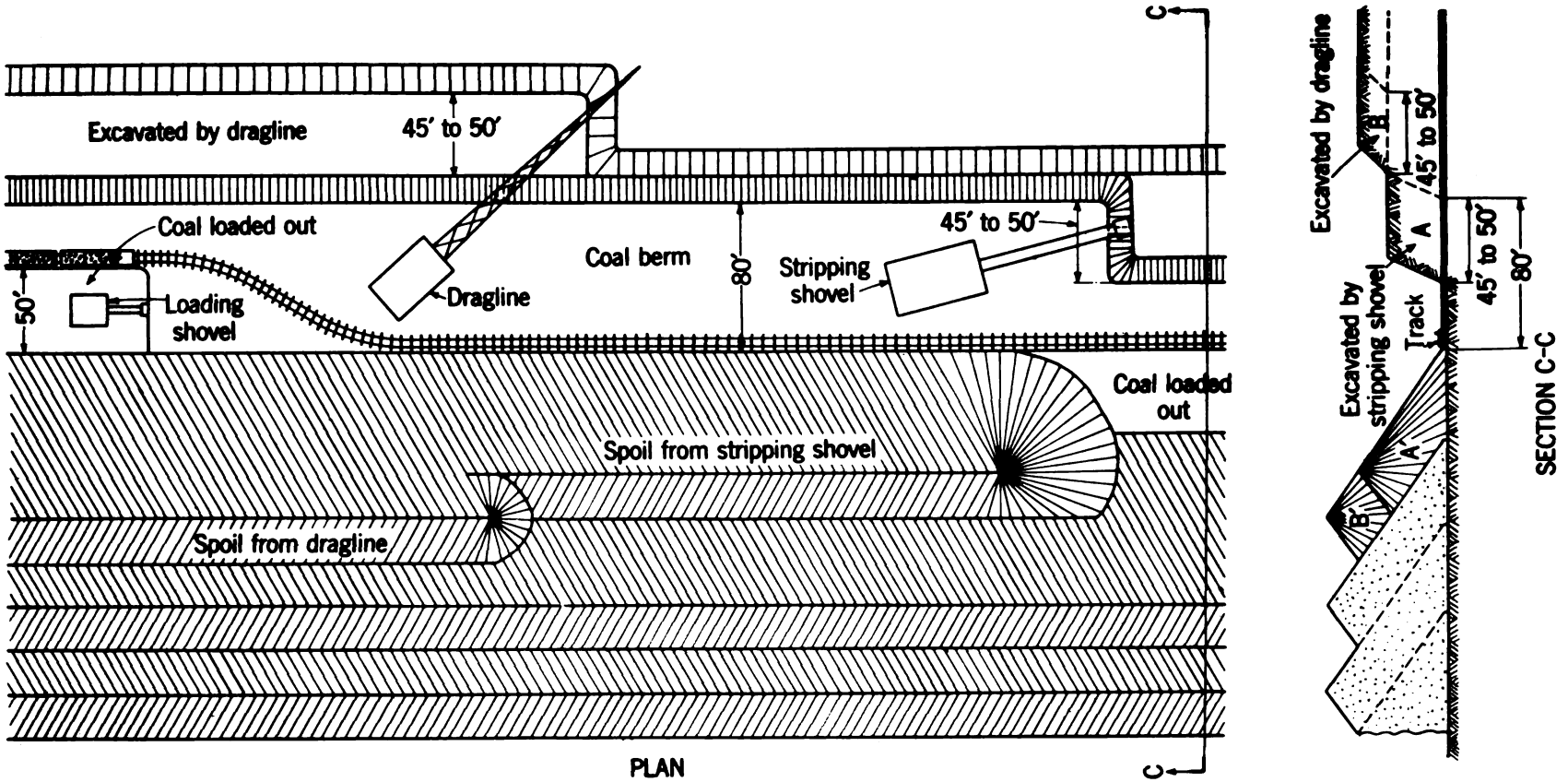


Figure 5.- Mining method in use at mine no. 8.

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the surface outside the workable coal area. After the box cut has been made, the coal is removed for an average width of 45 feet, leaving a 35- to 45-foot berm on which are the haulage tracks, while the stripping shovel digs the next cut.

In section 1, the shovel takes a cut averaging 50 feet in width from the high wall after the initial cut has been made and casts the spoil into the space, from which the coal has been removed.

The overburden in this section averages 20 feet in depth and approximately 700,000 cubic yards are moved per month.

In sections 2 and 3, where the overburden is approximately 50 feet thick, a dragline is used in conjunction with the shovel. The dragline works back of the shovel and takes the first third of the overburden from the next cut. The remaining two-thirds of the overburden is removed by the shovel. The position of the equipment is shown in figure 5. The cuts taken are 45 to 50 feet wide. The shovel deposits the spoil in the cut from which the coal has been taken, and the dragline casts its spoil back of that deposited by the shovel. The shovels advance approximately 10 feet per move, and the draglines move about 40 feet each time. A shovel and dragline will move approximately 625,000 cubic yards of overburden per month (400,000 cubic yards by shovel and 225,000 cubic yards by dragline.)

At section 4 the overburden is shallow and a dragline is used to uncover the coal. The width of the cut is approximately 45 feet. The width from high wall to spoil bank in all the sections averages 80 feet.

All stripping units operate three 8-hour shifts, but are limited to 172 hours per month by contract with the United Mine Workers of America. Additional or swing crews are used in order to operate the units full time during the month. A checker is used on each shovel to record the swings, secure measurements for yardage, mapping, and all-time and operating data made by the shovel.

## Coal Loading

The four operations use electric loading shovels equipped with dippers of 7, 4, 4, and 3 cubic yards capacity, respectively.

The width of the coal cuts made by these shovels is 40 to 50 feet. The coal is loaded into cars. These four shovels load an average of 165,000 tons per month. The shovels load one 7-hour shift per day and usually operate 6 days per week.

At some places where the coal does not break easily and it is necessary to drill and shoot it, pellet powder is used. Usually, however, the calcite joints that extend vertically through the seam cause the coal to break easily.



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## Haulage

Rail haulage over standard-gage track (4 feet 8½ inches) is used in all the sections. The track is on the coal, and it is laid at a distance from the spoil pile equal to the width of the coal cut, usually 45 feet. This places the track along the edge of the berm after the coal has been removed. After the coal has been loaded, the track is shifted the width of the next coal cut. The four loading shovels advance approximately 250 feet each per shift, and a total of 1,000 feet of track is shifted per day. Due to local dips of the coal, it is necessary to "block up" or ballast the track. If it is possible, a maximum grade of 2 percent is maintained; however, steeper grades sometimes exist.

The coal is loaded into standard railroad cars in two of the pits, and in the other two, 40-ton self-dumping cars are used. The cars are hauled in trips of 2 to 6 cars, depending upon the grade. Motive power is supplied by four 50-ton and one 42-ton geared-type locomotives and two 40-ton and two 30-ton gas-electric locomotives.

The average length of haul is 1½ miles one way to a central yard, from which the cars are hauled in trains by a railroad company to the tipple and washery.

## Drainage

Surface water is drained around the pits by ditches. The sand in the overburden contains water, which drains into the pits, where it is gathered in sumps and discharged by electric pumps to the surface. There are 12 to 15 electric pumps in each pit. These usually are of 350-gallon-per-minute capacity, having a 3-inch discharge and 4-inch suction. As a rule, there is also one pump in each pit with a 6-inch discharge.

## Preparation

The coal is dumped from cars into a hopper and conveyed to the tipple for preparation. The tipple is equipped with shaking screens, picking tables, and loading booms. The minus 3-inch coal is conveyed to the washer for further cleaning. The tipple has six loading tracks, and sizes are prepared according to demand. The tipple and washer usually operate two 7-hour shifts per day.

## Power

Electric power is purchased from a public utility company and is delivered to the transformer station at 33,000 volt (3-phase, 60-cycle, alternating current). It is stepped down to 4,400 volts for use on stripping shovels and draglines and to 2,300 volts for loading shovels. Drills and other electrical equipment operate on 220 volts.



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Summary

Shovel data (see tables 2 and 3).

| | |
|---|---|
| Average overburden per pound of explosive.....cubic yards | 15 |
| Average stripped per hour.....do. | 2,800 |
| Average coal uncovered per hour.....tons | 200 |
| Ratio of digging time to operating time.....percent | 80 |
| Average loaded per hour.....tons | 857 |
| Total power consumption per ton.....kw.-hr. | 11.5 |
| Average daily production, coal.....tons | 6,000 |

Mine employees, based on production of 6,000 tons per working day

| Class | Number of men | Hours worked per day | Days worked per week | Total man-hours per week |
|---|---|---|---|---|
| Drillers<br>Shooters..... | 12 | 7 | 7 | 588 |
| Stripping shovels:<br>Operator 1 x 3[1] x 3[2]<br>Oiler 1 x 3 x 3<br>Checker 1 x 3 x 3 .....<br>Groundmen 1 x 3 x 3 | 36 | 8 | 7 | 2,016 |
| Draglines:<br>Operator 1 x 3 x 3<br>Oiler 1 x 3 x 3<br>Checker 1 x 3 x 3.....<br>Groundmen 1 x 3 x 3 | 36 | 8 | 7 | 2,016 |
| Loading shovels 4 x 3..... | 12 | 7 | 6 | 504 |
| Locomotive crews 2 x 9..... | 18 | 7 | 6 | 756 |
| Trackmen 30 x 2..... | 60 | 7 | 6 | 2,520 |
| Tippel and washer 2 x 35.... | 70 | 7 | 6 | 2,940 |
| Miscellaneous:<br>Blacksmiths<br>Electricians.....<br>Mechanics | 18 | 7 | 6 | 756 |
| Others..... | 31 | 7 | 6 | 1,302 |
| Monthly..... | 10 | 8 | 6 | 480 |
| Supervision..... | 12 | 8 | 6 | 576 |
| | 315 | | | 14,454 |

1/ 2 machines.
2/ 3 shifts.



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Recapitulation on weekly basis, production 36,000 tons

| Class | Number of man-shifts | Total man-hours | Tons per man per shift | Man-hour per ton |
|---|---|---|---|---|
| Banking, drilling, and shooting... | 84 | 588 | 428.5 | 0.016 |
| Stripping..... | 504 | 4,032 | 71.4 | .112 |
| Loading..... | 72 | 504 | 500 | .014 |
| Haulage..... | 468 | 3,276 | 76.9 | .091 |
| Tipple..... | 420 | 2,940 | 85.7 | .082 |
| Miscellaneous..... | 354 | 2,538 | 101.7 | .070 |
| Supervision..... | 72 | 576 | 500 | .016 |
| | 1,974 | 14,454 | 18.3 | .401 |

Wage rates and working conditions are governed by contract between operators and the United Mine Workers of America. Extra men fill in vacancies caused by the 35-hour week limitation on certain classes of labor.

## Mine 9

This coal does not outcrop on the surface, which is flat, and it is located by drilling. It averages 6 feet in thickness. There is one parting $\frac{1}{4}$ to $1\frac{1}{2}$ inches thick approximately 18 inches from the bottom of the seam. Occasionally there are small lenses of pyrite. The seam follows the regional dips, but local dips do occur. At one place there was a difference in elevation of 25 feet in 1,400 feet. The overburden varies in thickness and character, but one section is as follows:

| | Feet |
|---|---|
| Surface soil and clay..... | 36 |
| Limestone..... | 16 |
| Hard shale..... | 2 |
| Coal..... | .... |

Where dips occur in the seam, there is usually a stratum of white, soft shale under the limestone. At some places the hard shale is absent, and the limestone is on top of the coal.

This mine consists of three sections, but only two are operated continuously. The third is put in operation during rush seasons.

### Drilling and Blasting Overburden

Three electric drills of the well type, mounted on caterpillars, are used in each section. Three rows of 10-inch-diameter holes are drilled parallel to the high wall for each cut. Holes are spaced on 30-foot centers and staggered in rows 27 feet apart. Usually they are drilled through the limestone into the shale above the coal. Approximately 85 feet of hole is drilled per drill shift when the limestone is 16 to 20 feet thick. The cost is approximately 23 cents per foot of hole drilled.



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The holes are charged with LOX, 8½ by 18 inches, having an effective weight of approximately 45 pounds per cartridge. Ordinarily one cartridge is used for every 2.8 feet of limestone. The charge is fired electrically with No. 8 detonators. As a rule, 10 to 14 holes are shot at a time. A log of each hole is kept, and the amount of explosive used is judged by the thickness of the limestone.

## Uncovering Coal

The following stripping equipment is used:

Section

1. Electric stripping shovel equipped with 120-foot boom, 84-foot stick, and 15-cubic-yard dipper.
2. Electric stripping shovel having a 90-foot boom, 64-foot stock, and 15-cubic-yard dipper.
   Electric dragline equipped with 170-foot boom and 12-cubic-yard dipper.
3. Electric stripping shovel equipped with a 90-foot boom, 64-foot stick, and 15-cubic-yard dipper.
   Electric dragline having a 170-foot boom and 14-cubic-yard dipper.

The practice is similar in sections 2 and 3, the only ones in operation at present. The same results are obtained at no. 1 with a single stripping unit and will not be discussed in detail.

The average depth of stripping is usually 55 feet. With tandem units, 85 feet of overburden can be dug if the units are kept on an outside curve. The dragline excavates the top 25 feet of the overburden, and the shovel removes the lower 30 feet. The depth of overburden removed is balanced between the two machines, so that the progress of both shovel and dragline is uniform. The dragline works on the coal back of the shovel and removes the overburden from the next cut. The dragline casts the spoil beyond the material wasted by the shovel (similar to figure 5). The width of the cut taken by the dragline is usually 50 feet, and that taken by the shovel is also 50 feet. The width of the pit from high wall to spoil bank is about 100 feet. The minimum width of the coal berm on which the shovel operates is equal to the height of the overburden. This practice tends to keep material from rolling off the high wall onto the loading track, which is on the edge of the coal berm. The shovel advances 10 feet when moving up, and the dragline advances approximately 30 feet.

Each stripping shovel in sections 2 and 3 will move approximately 5,600 cubic yards in 8 hours, and each dragline excavates 3,500 to 4,000 cubic yards per shift. The effective working time of each machine is from 80 to 85 percent.



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The surface of the coal is cleaned by the groundmen with shovels and a scraper attached to the dragline. The coal is washed at the preparation plant and careful cleaning in the pits is not necessary.

## Coal Loading

Each unit is equipped with an electrically operated coal-loading shovel. These shovels have a dipper of 4½ cubic yards capacity. One dipper is made of aluminum and the other of a steel alloy.

The coal is drilled with jackhammers, and holes are spaced on 10-foot centers and staggered. The holes are charged with 1 to 1½ sticks of pellet powder, depending upon the size of coal required, and fired electrically. The order of firing for obtaining the maximum proportion of lump coal is shown in figure 1. When small coal is wanted the holes are fired in rows at right angles to the track.

The shovel loads from a cut 50 feet wide, and approximately 3,400 tons of raw coal is loaded per shift by each shovel.

## Haulage

Rail haulage is used, and the track gage is standard (4 feet 8½ inches). Main-line track is constructed of 80-pound rail and that in the pit of 70-pound, all on wooden ties. The track is at the edge of the berm adjacent to the loading shovel. The cars have a capacity of 40 tons and are of the automatic drop-bottom type. Five cars are hauled per trip by a 42-ton geared locomotive. Where grades are steeper than 1¾ percent a booster locomotive is used. The length of haul varies. Three locomotives handle the production in each section of the mine until the length of haul exceeds 2 miles in one direction, when a fourth locomotive is added. There are five trackmen to each loading unit, and these men shift and maintain the track in the pit. The track is extended or shifted approximately 300 feet per shift.

## Drainage

Surface ditches are dug around the pit to take care of drainage, but some water accumulates in the workings and is collected in sumps and pumped out of the pit by electrically operated pumps.

## Preparation

The coal is dumped into a hopper at the tipple and is conveyed to shaking screens and washery. Approximately 12 percent of the raw coal is waste. This waste material is loaded into Western-type side-dump cars and transported to the pit for disposal.

The tipple is of steel construction and has seven loading tracks.



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## Power

Electric power is purchased from a public utility company. Alternating current is delivered at 33,000 volts, 3-phase, 60-cycle and is stepped down to 4,400 volts for use on stripping shovels and draglines. The main power line is outside the strip area. Laterals are spaced every 600 feet and extend to the edge of the pit. Shovels are equipped with 750-foot trailing cables. Drills operate on 440 volts and trench-lay cables 300 feet long extend from poles to a switch box from which they are operated.

## Summary

Shovel data (see tables 2 and 3).

| | |
|---|---|
| Average of overburden per pound of explosive.....cubic yards | 10.5 |
| Average stripped per hour.....do. | 2,400 |
| Average coal uncovered per hour.....tons | 260 |
| Ratio of digging time to working time.....percent | 80 |
| Average raw coal loaded per hour.....tons | 970 |
| Average daily production clean coal.....do. | 6,000 |



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Mine employees, based on production of 6,000 tons per working day
(2 sections)

| Class | Number of men | Hours worked per day | Days worked per week | Total man-hours per week |
|---|---|---|---|---|
| Drillers<br>Helpers<br>Shooters | 30 | 7 | 5 | 1,050 |
| Stripping shovels:<br>Operator 2[1] x 3[2]<br>Oiler 2 x 3<br>Groundmen 2 x 3 | 18 | 8 | 6 | 864 |
| Draglines:<br>Operator 2[1] x 3[2]<br>Oiler 2 x 3<br>Groundmen 2 x 3 | 18 | 8 | 6 | 864 |
| Loading shovels:<br>Operator 2 x 1<br>Groundmen 2 x 2 | 6 | 7 | 5 | 210 |
| Coal drilling and shooting 2 x 3 | 6 | 7 | 5 | 210 |
| Locomotive engineers | 7 | 7 | 5 | 245 |
| Locomotive brakemen | 3 | 7 | 5 | 105 |
| Trackmen | 16 | 7 | 5 | 560 |
| Tipple | 48 | 7 | 5 | 1,680 |
| Mechanics and helpers | 7 | 7 | 5 | 245 |
| Electrician and helpers | 9 | 7 | 5 | 315 |
| Shopmen | 12 | 7 | 5 | 420 |
| Miscellaneous: | | | | |
| Teamsters | 4 | 7 | 5 | 140 |
| Locomotive hostlers | 3 | 7 | 5 | 105 |
| Truck drivers | 2 | 7 | 5 | 70 |
| Wash house | 1 | 7 | 5 | 35 |
| Watchman | 1 | 7 | 5 | 35 |
| Carpenters and helpers | 2 | 7 | 5 | 70 |
| Repairmen | 2 | 7 | 5 | 70 |
| Pumpers | 6 | 7 | 5 | 210 |
| Monthly men | 12 | 8 | 6 | 576 |
| | 213 | | | 8,079 |

1/ 2 machines.
2/ 3 shifts.



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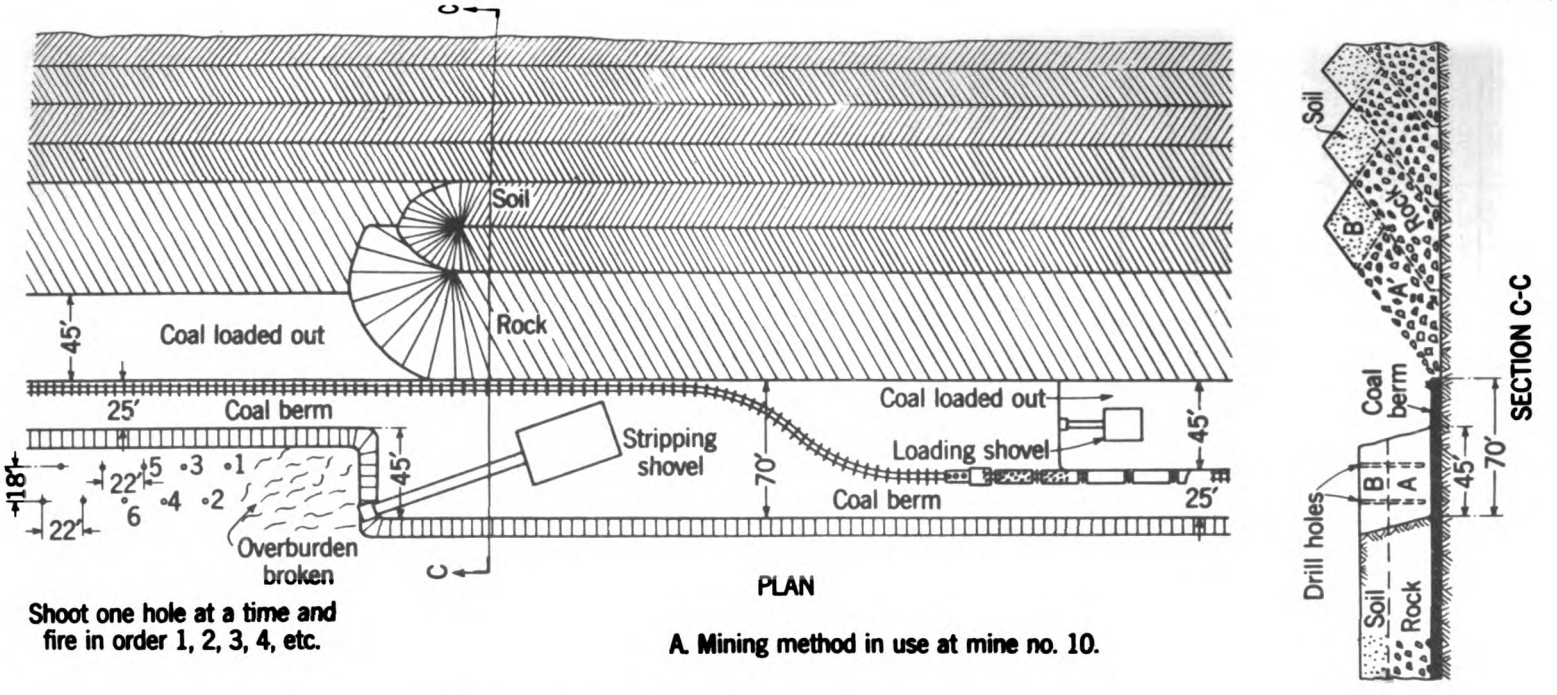
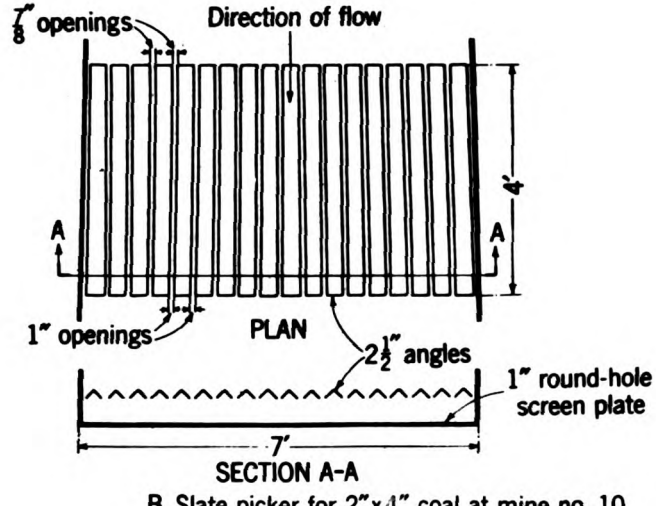



Shoot one hole at a time and fire in order 1, 2, 3, 4, etc.

A. Mining method in use at mine no. 10.




B. Slate picker for 2"x4" coal at mine no. 10.

Figure 6.

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Recapitulation on weekly basis, production 30,000 tons

| Class | Number of man-shifts | Total man-hours | Tons per man per shift | Man-hour per ton |
|---|---|---|---|---|
| Bank drilling and shooting... | 150 | 1,050 | 200 | 0.035 |
| Stripping..... | 216 | 1,728 | 138.8 | .058 |
| Loading..... | 60 | 420 | 500 | .014 |
| Haulage..... | 130 | 910 | 230.7 | .030 |
| Tipple..... | 240 | 1,680 | 125 | .056 |
| Miscellaneous..... | 293 | 2,099 | 102.4 | .070 |
| Supervision..... | 24 | 192 | 1250 | .006 |
| | 1,113 | 8,079 | 26.9 | 0.269 |

Mine 10

The topography of the area is comparatively level. The coal, which averages 6 feet thick, is located by drilling either with hand or power drills. The overburden varies in thickness, but an average section is as follows:

| | Feet |
|---|---|
| Surface soil, clay, and boulders..... | 23 |
| Shale..... | 6 |
| Limestone..... | 10 |
| Coal..... | 5.8 |

In some places there is a thin stratum of black shale between the limestone and the coal. The bottom is fireclay.

Drilling and Blasting Overburden

Vertical holes are drilled with a well-type drilling rig. The holes are 6 inches in diameter, are spaced on 22-foot centers, and are staggered in rows 18 feet apart. Eight electrically operated drills, are employed and usually operate three shifts per day. Approximately two holes are drilled in each shift by each drill, an average of 77 feet. The cost per foot of hole drilled averages 21 cents.

The holes are charged with LOX and fired with an electric detonator placed in a stick of dynamite. The order of firing is shown in figure 6-A. The amount of explosive used is governed by the thickness of the limestone in the overburden. Usually one bag 5 inches diameter by 20 inches and having an effective weight of 12½ pounds is used for each 2 feet of limestone. The shooting crew consists of three shot-firers, who work one shift per day. Approximately 4.33 cubic yards of overburden is broken per pound of explosive.



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## Uncovering Coal

At the time this property was visited, the stripping unit was an electrically operated shovel equipped with a 95-foot boom, 64-foot dipper stick, and 18-cubic-yard dipper. The length of the pit is approximately $1\frac{3}{4}$ miles, and cuts, usually 45 feet in width, are made from the high wall. The width of cut from high wall to spoil bank averages 70 feet. Figure 6A shows the position of the shovel with relation to the tracks and loading shovel. The normal operating crew is a shovel operator, an oiler, and a groundman on each shift. Approximately 600 cubic yards of overburden is stripped per hour, and the digging time averages 78 percent of the working time.

The surface of the coal is cleaned with two tractor-operated bulldozers.

## Coal Loading

The coal is drilled and shot before loading. Holes are drilled with a jackhammer and usually are spaced on 10-foot centers. The holes are charged with a stick of pellet powder and fired with an electric detonator.

The loading shovel is electrically operated and is equipped with a 5-cubic-yard dipper. This shovel removes the coal from a cut 45 feet wide and loads it into cars placed on the track at the edge of the cut. The loading crew consists of a shovel operator, an oiler, and five groundmen. Two of these groundmen clean the spillage from the tracks.

## Haulage

Rail haulage is used throughout the operation. Track gage is 36 inches. The depth to the coal was determined by drilling, and the stripping limits were established on the basis of the maximum allowable depth of stripping. The track was constructed outside this limit approximately parallel to the long axis of the area. At the far end of the area and, in a general way, at right angles to it a runway was built to the opening cut. The track was placed on the coal and extended along the berm the length of the pit. At the near end of the opening cut another runway was built from the pit to the surface, and the track extended to a junction with the line from the tipple. The empty trips of cars enter the pit at the far end, pass the loading shovel, leave the pit at the near runway, and pass to the tipple. Haulage is continuous, and there are no delays occasioned by waiting at passing tracks. The total length of the haul from tipple to pit and return is approximately 9 miles, but as the area is depleted, the length of haul is shortened. The width of the area becomes less with each cut, thus shortening the length of track at each end of the pit.

Cars are either of the drop-bottom or side-dump type and are of three sizes, having capacities of 5, 9, and 25 tons, respectively. Trips usually consist of 3 to 10 cars, an average of 80 tons. There are nine trains



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in use; and, on the average, eight trips are made per hour, or a little less than one trip per train per hour. Water supply for the locomotives is pumped from a creek to a central water tank.

## Drainage

Surface drainage is diverted from the pit by ditches, and the water that accumulates in the pit is pumped to the surface with electric pumps.

## Preparation

The tipple is equipped with hanger-type shaking screens, picking tables, and loading booms. The minus 1¼-inch and occasionally minus 2-inch is sent to the washer for final preparation. Sizes are prepared according to demand.

Part of the impurities in the raw coal is in the form of thin, flat pieces of shale. The majority of this shale is found in the 2- by 4-inch coal. This coal is passed over a slate picker, which is constructed of 2½-inch angles. The angles are placed parallel to the flow of the coal with the edge up. The edges of the angles are spaced 7/8 inch apart at the upper end and 1 inch apart at the lower end. This prevents wedging of the shale. As the coal and shale pass over this picker, the flat pieces of shale (and any minus 1-inch coal present) slide into the slot between the angles and pass to a 1-inch round-hole screen, which removes minus 1-inch coal, and the shale is shaken off onto a waste conveyor. The 2- by 4-inch coal passes over the angles to a screen for further preparation. The distance between angles can be adjusted for different sizes of coal. Figure 6,B, is a sketch of this slate picker. The 1¼- by 2-inch coal also passes over a slate picker, the angles being spaced ½ inch apart at upper end and ¾ inch apart at lower end. An average of less than 12 percent of the waste product is coal.

## Power

All power is purchased from a public utility company and is 33,000-volt, 3-phase, 60-cycle alternating current. This voltage is stepped down by transformers to 4,000 volts for use on the stripping shovel and on the loading shovel and 220 volts on drills and pumps and tipple motors. Average power consumption for the entire plant is approximately 639,000 kw.-hr. per month.

## Summary

Shovel data (see tables 2 and 3).

| | |
|---|---|
| Average of overburden per pound of explosive.....cubic yards | 4.33 |
| Average stripped per hour.....do. | 600 |
| Average coal uncovered per hour.....tons | 100 |
| Ratio of digging time to working time.....percent | 73 |
| Average clean coal loaded per hour.....tons | 608 |
| Average daily production clean coal.....do. | 4,250 |



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Mine employees, based on production of 4,250 tons per working day

| Class | Number of men | Hours worked per day | Days worked per week | Total man-hours per week |
|---|---|---|---|---|
| Drillers 1 x 8 x 3[1]..... | 24 | 7 | 7 | 1,176 |
| Helpers ½ x 8 x 3..... | 12 | 7 | 7 | 588 |
| Miscellaneous..... | 2 | 7 | 7 | 98 |
| Shooters..... | 3 | 7 | 7 | 147 |
| Stripping shovel: Operators 1 x 3[1] Oilers 1 x 3..... Groundmen 1 x 3 | 9 | 8 | 7 | 504 |
| Cleaning and shooting coal.. | 7 | 7 | 4 | 196 |
| Loading shovel: Operator 1 Oiler 1..... Groundmen 5 | 7 | 7 | 4 | 196 |
| Locomotive engineers..... | 9 | 7 | 5 | 315 |
| Locomotive tenders..... | 2 | 7 | 7 | 98 |
| Water supply..... | 3 | 7 | 7 | 147 |
| Trackmen..... | 21 | 7 | 5 | 735 |
| Tipple..... | 44 | 7 | 4 | 1,232 |
| Electricians and helpers.... | 7 | 7 | 6 | 294 |
| Pumpmen..... | 3 | 7 | 7 | 147 |
| Shop..... | 17 | 7 | 7 | 833 |
| Truck drivers..... | 6 | 7 | 5 | 210 |
| Miscellaneous..... | 11 | 7 | 4 | 308 |
| Monthly men..... | 11 | 8 | 7 | 616 |
| Supervision..... | 11 | 8 | 7 | 616 |
| | 209 | | | 8,456 |

1/ 3 shifts.

Recapitulation on weekly basis, production 17,000 tons

| Class | Number of man-shifts | Total man-hours | Tons per man per shift | Man-hour per ton |
|---|---|---|---|---|
| Bank drilling and shooting... | 287 | 2,009 | 59.2 | 0.118 |
| Stripping..... | 63 | 504 | 269.8 | .029 |
| Loading..... | 56 | 392 | 303.5 | .023 |
| Haulage..... | 185 | 1,295 | 91.8 | .076 |
| Tipple..... | 176 | 1,232 | 96.6 | .073 |
| Miscellaneous..... | 333 | 2,408 | 51.1 | .142 |
| Supervision..... | 77 | 616 | 220.8 | .036 |
| | 1,177 | 8,456 | 14.4 | .497 |

All wage rates and working conditions are governed by contract with the United Mine Workers of America, and "swing" crews are used to conform to a 35-hour week for occupations so specified in the contract.



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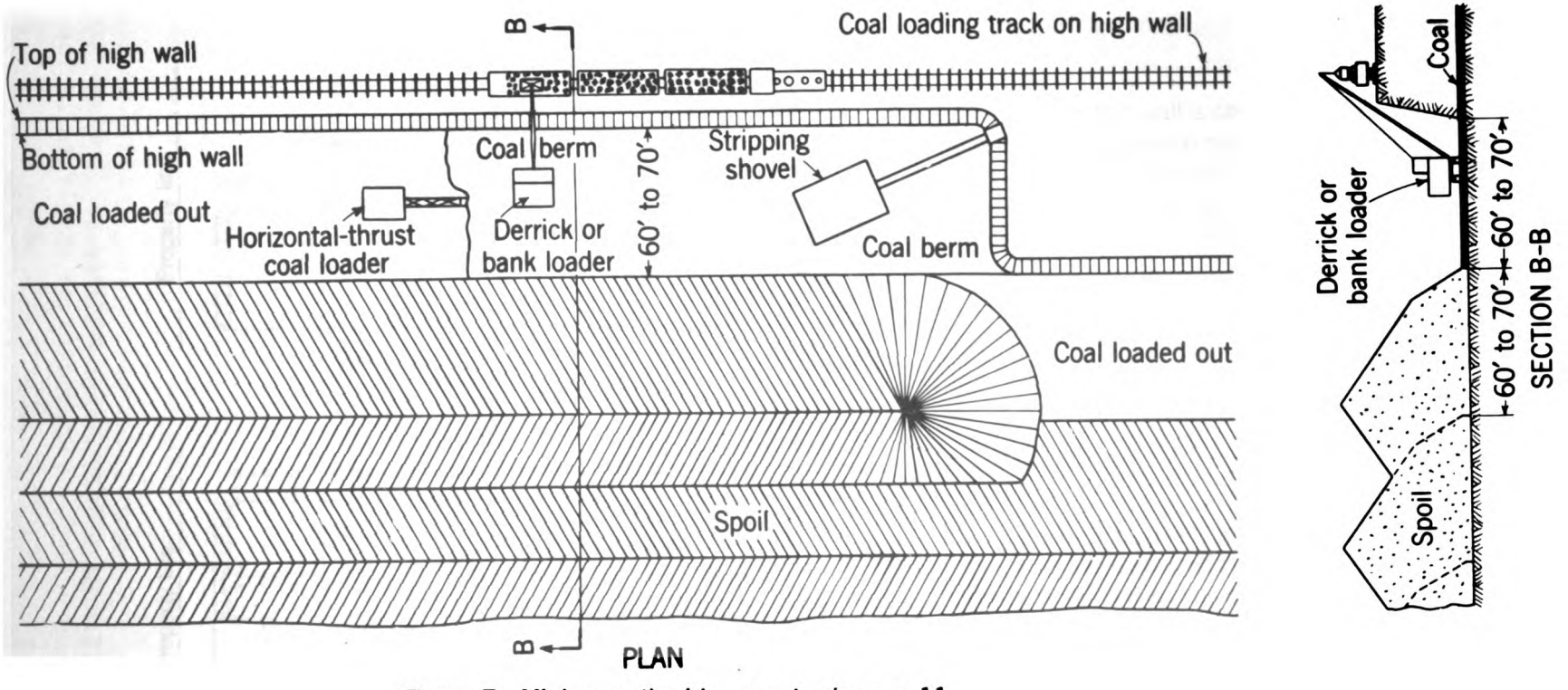


Figure 7.–Mining method in use at mine no. 11.

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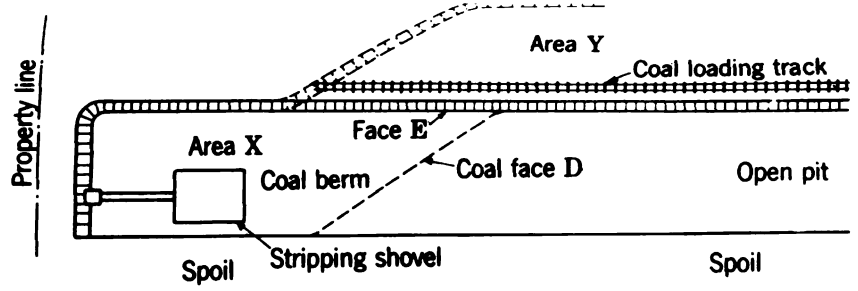
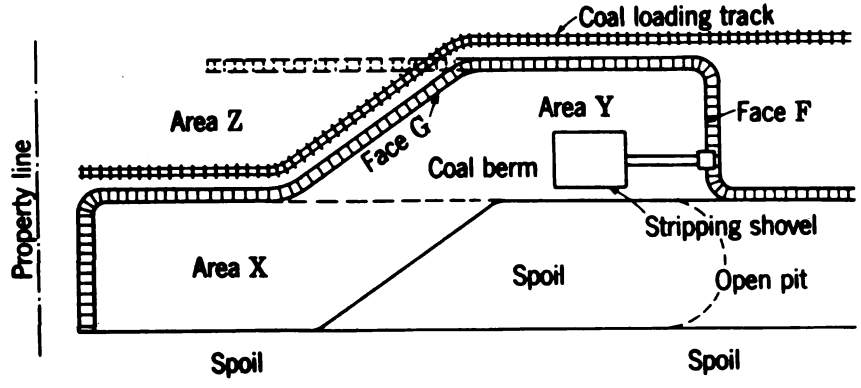
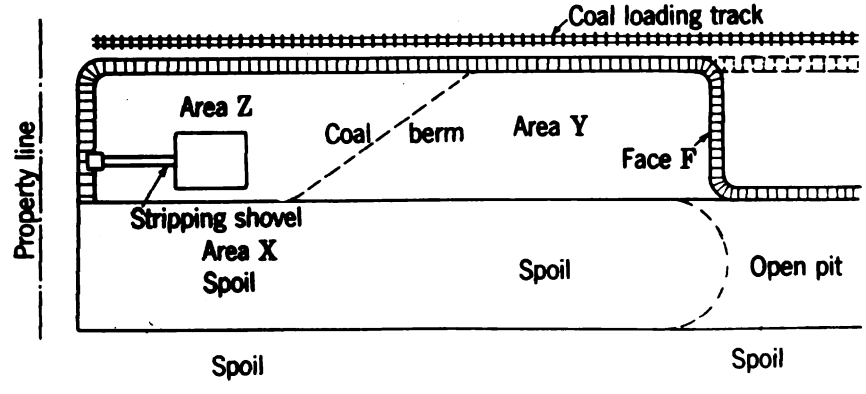



(a) Stripping shovel remains in this position until coal is loaded out of open pit to coal face D. Loading machines are moved to left end of pit to load area X. Shovel turns and deadheads to face E and starts cut into area Y.




(b) Cut in high wall is continued to face F while coal is being loaded out from area X; then shovel turns and deadheads to face G and starts cut into area Z. Loading machines remain in area Y near the high wall while area Z is being uncovered.




(c) Spoil from area Z is dumped into area X. When area Z is uncovered the shovel deadheads back to face F and loading machines are moved to area Z and follow shovel to other end of the pit.

Figure 8.–Method of turning at end of cut.

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## Mine 11

This property is on a rolling prairie. The coal averages 32 inches in thickness and does not outcrop on the property but lies at an average depth of 40 feet. The regional dip is to the northwest, and the dip of the coal follows this general direction. There are local dips, however. The coal is free from partings, but there are numerous clay veins or horsebacks throughout the coal area. A section of the overburden is as follows:

| | Feet | Inches |
|---|---|---|
| Surface soil and clay..... | 21 | ..... |
| Light shale..... | 10 | ..... |
| Hard blue shale..... | 9 | ..... |
| Coal..... | 2 | 8 |
| Fireclay..... | .... | ..... |

### Drilling and Blasting Overburden

The overburden is drilled, where necessary, with an electrically operated, horizontal, auger-type drill. The holes are 4 inches in diameter and are placed 4 feet above the coal and drilled 60 to 70 feet deep on 42-foot centers. They are charged with approximately 200 pounds of 40-percent gelatin dynamite per hole and fired with electric detonators. If the hard-shale stratum above the coal is not broken sufficiently, the overburden is removed from the top of this hard shale for a distance of about 10 feet, forming a bench. This bench is drilled with a jackhammer and charged with about three sticks of 20-percent dynamite per hole and fired electrically. The character of the overburden in some places is such that the stripping shovel can dig the material without it being blasted, hence a figure on the number of cubic yards of overburden per pound of explosive might be misleading. This is computed by dividing the total number of cubic yards of overburden moved during a certain period by the pounds of explosives used for the same period.

### Uncovering Coal

The stripping unit is an electrically operated shovel equipped with a 97-foot boom, 56-foot dipper stick, and 18-cubic yard dipper. This dipper is to be replaced with one of 23 cubic yards capacity. The property was opened with a box cut and successive cuts are being made 70 feet wide, which is also the distance from high wall to spoil bank. (See fig. 7). The method of turning the shovel upon reaching the end of the property or for any other reason and starting a new cut is shown in figure 8.

### Coal Loading

The surface of the coal is cleaned with a Fresno scraper drawn by a tractor.



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An electrically operated, horizontal-thrust, (skimmer), coal-loading shovel equipped with 4½-cubic-yard dipper is used (fig. 9-B). This shovel removes the coal from the width of the cut, 70 feet. The coal is loaded into a 9-ton skip of a derrick or bank machine having a 90-foot boom. When the skip is filled it is raised and dumped into cars on the high wall. The bank machine is electrically operated and is mounted on crawlers (caterpillars). It is moved ahead as the loading shovel advances (see fig. 7).

## Haulage

Rail haulage is used from the loading point to the tipple. The topography of the property and the characteristics of the overburden, whereby it stands nearly vertical without caving, make it possible to maintain the haulage and loading tracks on the high wall. The edge of the ties is placed approximately 10 feet from the edge of the high wall. Track gage is 36 inches. The track is shifted the full width of a cut, 70 feet, when a new cut is to be made. (See fig. 8.) Usually, the track is shifted in sections of 4-rail lengths by a crew of five men using a tractor. After the track has been placed in its new position the sections are connected, lined, leveled, and surfaced by a crew of seven men.

The cars, which are of the drop-bottom type, have a capacity of 15 tons and are hauled by a steam saddle-type locomotive in trips of five cars each. The length of haul one way is approximately 3 miles. There are two passing tracks between tipple and loading point. One locomotive makes about five trips per day from loading point to tipple.

## Drainage

Surface water is diverted from the mine by ditches, and water that accumulates in the mine is discharged to the surface by electrically operated pumps.

## Preparation

The tipple has five loading tracks and is equipped with shaking screens, picking tables, and loading booms. The loaded trips are run over a hopper and the cars are dumped automatically. The coal is conveyed to the tipple for sizing and preparation. The size of the different grades of coal varies with the demand.

## Power

All electric power is purchased from a public utility company and is 3-phase, 60-cycle alternating current. Total power consumption per ton of coal averages 8.6 kw.-hr. The stripping unit consumes approximately 78.3 percent of the total power used.



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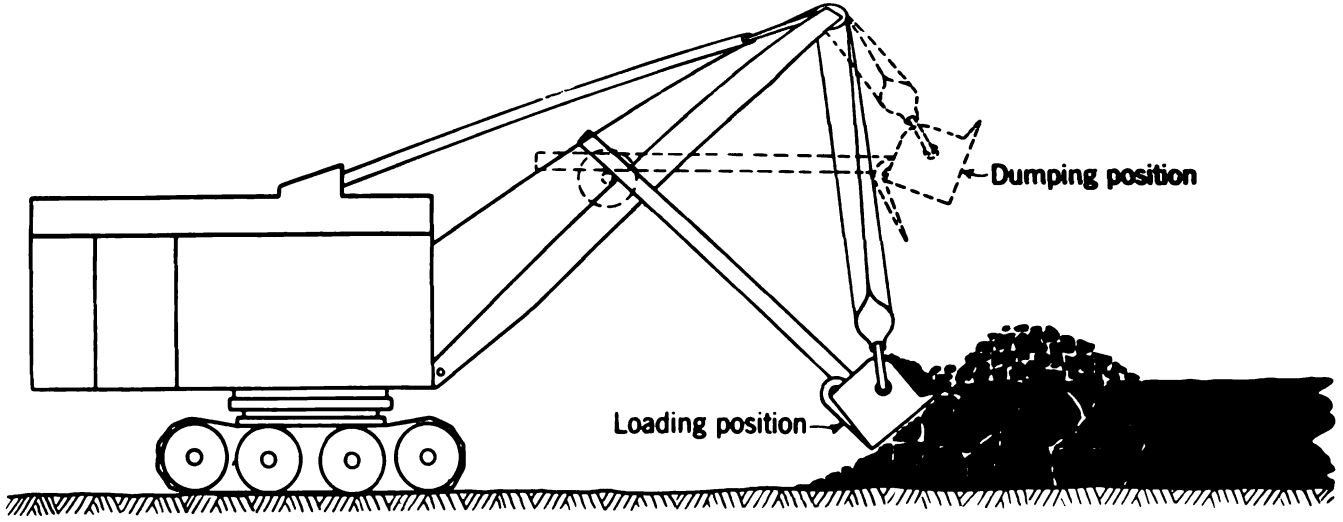
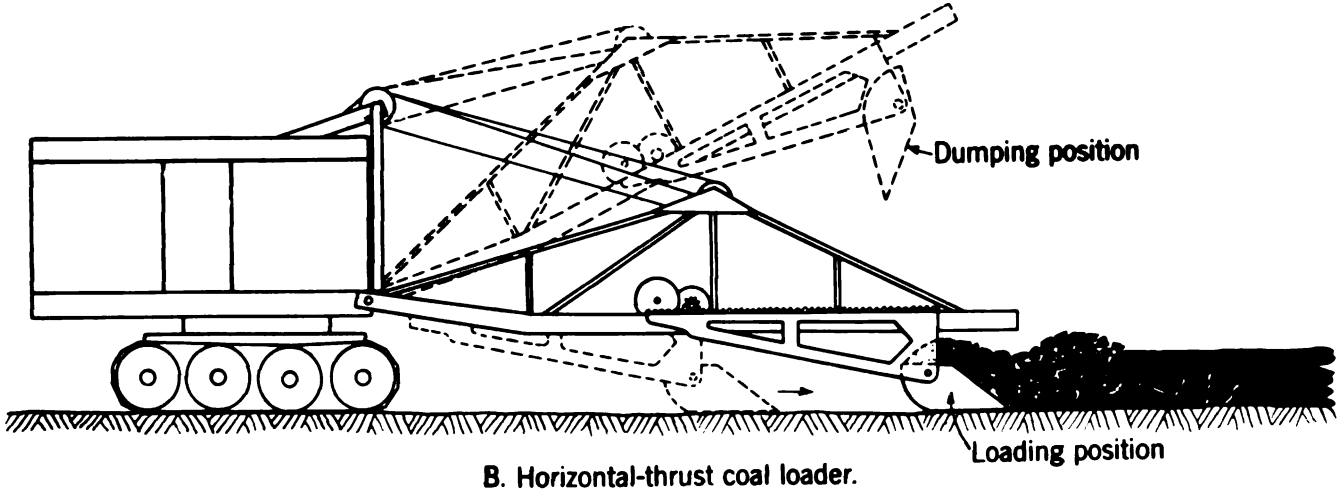



A. Coal-loading shovel.




B. Horizontal-thrust coal loader.

Figure 9.

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Summary

Shovel data (see tables 2 and 3).

| | |
|---|---|
| Average of overburden stripped per hour.....cubic yards | 975 |
| Average coal uncovered per hour.....tons | 53 |
| Ratio of digging time to working time.....percent | 79.5 |
| Power consumption per ton of coal.....kw.-hr. | 8.6 |
| Average daily production of coal.....tons | 1,600 |

Mine employees, based on production of 1,600 tons per working day

| Class | Number of men | Hours worked per day | Days worked per week | Total man-hours per week |
|---|---|---|---|---|
| Drillers and shooters..... | 2 | 7 | 5 | 70 |
| Stripping shovel: Operator 1 x 3[1] / Oiler 1 x 3..... / Groundmen 2 x 3 | 12 | 8 | 7 | 672 |
| Loading shovel..... | 2 | 8 | 6 | 96 |
| Men around loading shovel.... | 5 | 7 | 5 | 175 |
| Bank machine..... | 2 | 7 | 6 | 84 |
| Cleaning and shooting coal... | 8 | 7 | 5 | 280 |
| Locomotive crew..... | 5 | 7 | 5 | 175 |
| Trackmen..... | 12 | 7 | 5 | 420 |
| Tipple..... | 20 | 7 | 5 | 700 |
| Miscellaneous..... | 10 | 7 | 5 | 350 |
| Monthly men..... | 4 | 8 | 6 | 192 |
| Supervision..... | 5 | 8 | 6 | 240 |
| | 87 | | | 3,454 |

1/ 3 shifts.

Recapitulation on weekly basis, production 8,000 tons

| Class | Number of man-shifts | Total man-hours | Tons per man per shift | Man-hour per ton |
|---|---|---|---|---|
| Bank drilling and shooting... | 10 | 70 | 800.0 | 0.009 |
| Stripping..... | 84 | 672 | 95.2 | .084 |
| Loading..... | 89 | 635 | 89.9 | .079 |
| Haulage..... | 85 | 595 | 94.1 | .074 |
| Tipple..... | 100 | 700 | 80.0 | .087 |
| Miscellaneous..... | 74 | 542 | 108.1 | .068 |
| Supervision..... | 30 | 240 | 266.7 | .030 |
| | 472 | 3,454 | 17.0 | .431 |



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## Mine 12

The topography of the area in which this mine is situated is rough, and the coal is exposed at places on the sides of deep valleys. Two beds are mined, and an average section showing the strata is as follows:

| | Feet | Inches | |
|---|---|---|---|
| Surface soil and clay | 27 | 6 | |
| Limestone | 5 | ..... | |
| Hard black shale | 3 | 6 | |
| Coal | 1 | 2 | |
| Hard gray shale | 13 | 2 | |
| Coal | 2 | 10 | 42-inch seam |
| Hard shale | 0 | 7 | |
| Coal | 0 | 8 | |
| Fireclay | 1 | 6 | |
| Limestone | .... | ..... | |

### Drilling and Blasting Overburden

Both horizontal and vertical holes are drilled. Horizontal holes are drilled in the black shale approximately 2 feet above the 14-inch seam of coal. These holes, which are 4 inches in diameter, are drilled with an electrically driven auger. They are usually drilled to a depth of 60 feet and spaced on 30-foot centers. The holes are charged with 3½- by 16-inch, 40-percent gelatin dynamite and fired with a No. 6 electric detonator.

After the overburden and 14-inch seam of coal have been removed (method described under Uncovering Coal), the 13-foot gray-shale stratum over the 42-inch coal is drilled vertically with an auger-type drill. Holes are 3 inches in diameter, spaced on 20-foot centers, and staggered. They are drilled to within 18 or 20 inches of the coal. Each hole is charged with 9 to 11 pounds of 2½- by 18-inch, 40-percent gelatin dynamite and fired with a No. 6 electric detonator. Figure 10 shows position of drill holes.

Approximately 11.5 cubic yards of overburden is shot per pound of explosive.

Two drills are operated, one horizontal and one vertical. There are usually two men to each drill. The drillers also do the shooting.

### Uncovering Coal and Coal Loading

This operation is unique since two seams, one overlying the other, are recovered. (Fig. 10.) The width of the stripping area is governed by the slope of the hills. The cuts follow the surface contours and are usually opened by making a box cut on the 42-inch seam where the overburden is 12 to 14 feet thick. It has been found that the coal at this depth has not deteriorated because of weathering.



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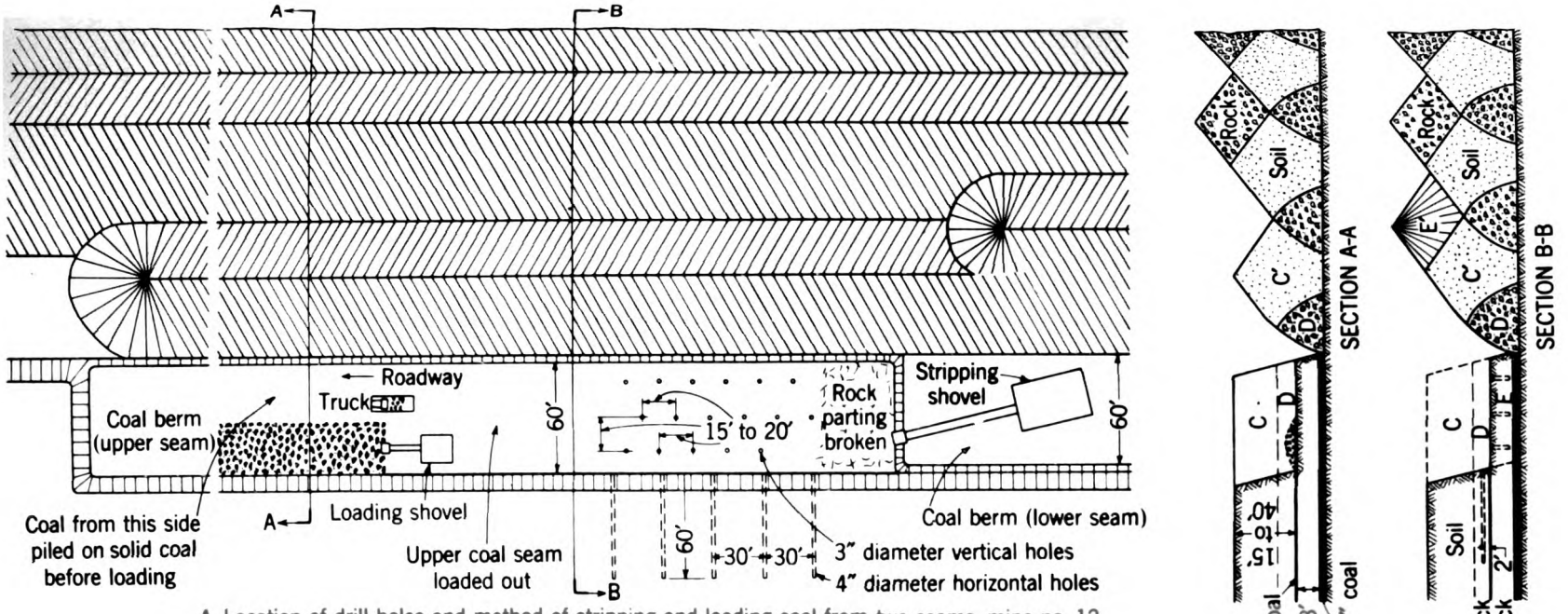
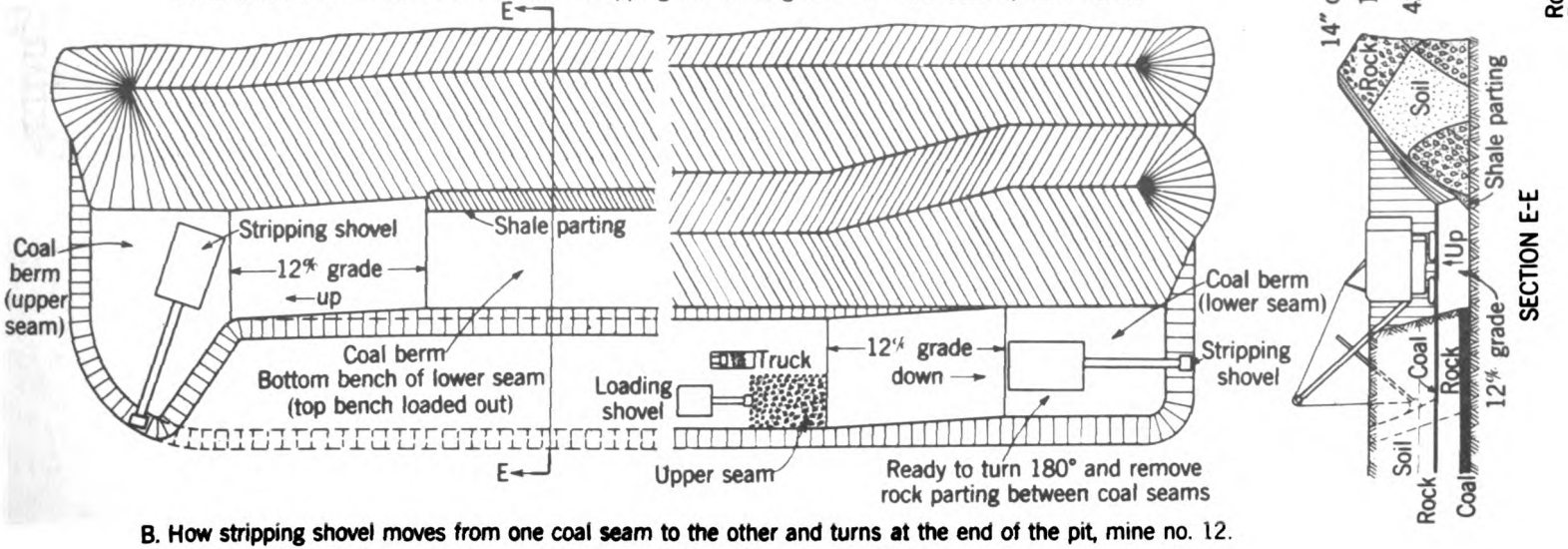



A. Location of drill holes and method of stripping and loading coal from two seams, mine no. 12




B. How stripping shovel moves from one coal seam to the other and turns at the end of the pit, mine no. 12.

Figure 10.

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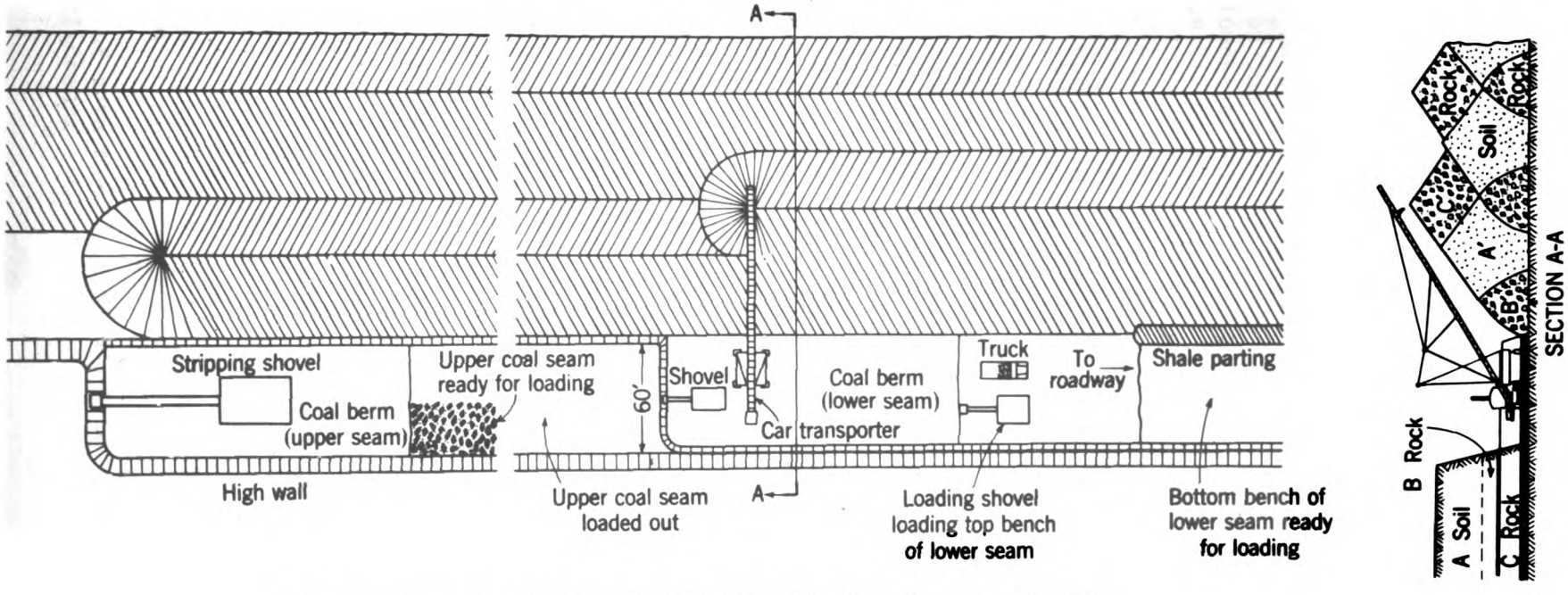


Figure 11.–How car transporter (stacker) is used in mining two-coal seams, mine no. 12.

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The main stripping shovel is electrically operated and is equipped with a 95-foot boom, 58-foot dipper stick, and 12½-cubic-yard dipper. The box cut is 60 to 80 feet wide and follows the contour of the hill, usually to the property line. As the stripping shovel advances, the 42-inch seam of coal is loaded into trucks by an electrically operated shovel equipped with a 2¾-cubic yard, coal-loading dipper. (See fig. 11.) This shovel loads the top section of the coal above the 6- to 8-inch parting. An electrically operated shovel equipped with a 4-cubic-yard dipper removes the parting and casts it on the edge of the spoil pile next to the coal. The lower 8 inches of the coal is then loaded by a gas-electric shovel equipped with a 1½-cubic-yard dipper. This coal is also loaded into trucks.

When the stripping shovel is near the end of the box cut, it makes a cut on a 12-percent grade up to a level on top of the 14-inch seam. After it has leveled off on top of the upper seam it turns and starts a cut 60 to 70 feet wide, casting the overburden into the area from which the 42-inch coal has been removed. (See fig. 10.) The stripping shovel is followed by the small loading shovel. This shovel removes the coal from the outside half of the width of the cut and places this broken coal on top of the solid half against the high wall for a distance of several hundred feet. Then the solid and loose coal is loaded into trucks at one operation. (See fig. 10.)

When the cut is nearly completed over the 14-inch seam, the stripping shovel cuts down a 12-percent grade to the top of the 42-inch seam and turns around and removes the 13-foot shale parting (after the 14-inch coal seam has been loaded out), casting it back of the spoil pile made from overburden over the 14-inch seam. (See fig. 10.) The loading shovels follow the stripping shovel, as previously described. When the stripping shovel nears the end of the cut, it again cuts up a 12-percent grade, levels off, turns on top of the 14-inch seam, and proceeds as described. The stripping of the two seams continues until a maximum depth of 55 feet, in a few instances 60 feet, from the surface to top of the 42-inch seam has been reached.

At times the large stripping shovel remains on top of the 14-inch seam, and the 13-foot interval over the 42-inch seam is removed by the electrically operated shovel equipped with a 4-cubic-yard dipper. When this is done, the spoil material is loaded into a car of a specially designed stacker, which moves on caterpillar mountings and follows the 4-cubic-yard shovel. The stacker (car transporter) consists of a car having a capacity of 4 cubic yards, which operates on an incline track suspended from a central "A" frame mounting and extending over the far edge of the spoil from the upper strata of overburden. This car is pulled over the track by an electric hoist, dumps automatically, and returns to the loading position by gravity. The round trip is made in approximately the same time as the shovel cycle. The stacker advances independently of the shovel, but with it. The two act as a dual unit for stripping. (See fig. 11.)

The surface of both the 14-inch and 42-inch seams is cleaned with a tractor-operated bulldozer.



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## Haulage

Truck haulage is used from coal face to tipple. The main road is constructed from the tipple to the stripping area. Lateral roads are built from the main road at approximately 1,000-foot intervals. The topography of the area is such that the stripping areas are not continuous but are separated from one another.

The roads are located, ditches dug to take care of surface drainage, and culverts and bridges built. The original subbase of the road was built of burned mine shale approximately 12 inches thick and 30 to 50 feet wide. This base was then surfaced with 3 inches of crushed rock and oiled. After mining began, extensions to the road were built of tipple refuse for the subbase and gravel for surfacing. These roads are also treated with oil. Maximum grades vary from 5½ to 6 percent but the maximum grade on new roads is kept below 5 percent. The average length of haul is 4½ miles, or 9 miles the round trip.

The main haulage units consist of 9 trucks with 15-ton capacity trailers. The 8-inch bottom bench of coal from the 42-inch seam is hauled by contract with one 10-ton and five 6-ton trucks. These trucks work intermittently.

A crew of three men and a road maintainer keep the roads in good condition.

## Drainage

Surface ditches are dug with a dragline. Water that cannot be drained from the pits by gravity is gathered into sumps and pumped to the surface with electrically operated pumps.

## Preparation

The coal is dumped from the trucks into a 75-ton hopper at the tipple and is fed by a reciprocating feeder to a conveyor and passed to the shaking screens for sizing. All sizes above 3 inches are hand-picked on tables, and the minus 3-inch is passed to the washer for further preparation. Sizes are prepared according to demand. The tipple is equipped with four railroad tracks for loading into cars.

## Power

All power is purchased from a public utility company and is alternating current, 33,000 volts, 3-phase, 60-cycle. It is stepped down by transformers to the voltage required by the various units. Power consumption averages 350,000 kw.-hr. per month.



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Summary

Shovel data (see tables 2 and 3).

| | |
|---|---|
| Average overburden per pound of explosive.....cubic yards | 11.5 |
| Average stripped per hour.....do. | 400 |
| Average raw coal uncovered per hour.....tons | 47 |
| Average clean coal loaded per hour.....do. | 243 |
| Average daily production clean coal.....tons | 1,700 |

Mine employees, based on production of 1,700 tons per working day

| Class | Number of men | Hours worked per day | Days worked per week | Total man-hours per week |
|---|---|---|---|---|
| Drillers and shooters..... | 4 | 7 | 5 | 140 |
| Stripping shovel: | | | | |
| Operator 1 x 3[1] / Oiler 1 x 3 ..... | 6 | 8 | 7 | 336 |
| Groundmen..... | 4 | 6 | 7 | 168 |
| Shovel (4 cubic yards) 2 x 2..... | 4 | 7 | 4 | 112 |
| Loading shovels: | | | | |
| 2¾-cubic yard shovel including coal cleaners..... | 12 | 7 | 4 | 336 |
| 1½-cubic yard shovel including coal cleaners..... | 5 | 7 | 4 | 140 |
| Truck operators..... | 9 | 7 | 4 | 252 |
| Truck operators (contract)..... | 6 | 7 | 4 | 168 |
| Road men..... | 3 | 7 | 5 | 105 |
| Tipple and washer..... | 22 | 7 | 4 | 616 |
| Shop: | | | | |
| Electricians / Mechanics ..... | 8 | 7 | 5 | 280 |
| Miscellaneous..... | 12 | 7 | 5 | 420 |
| Monthly men..... | 3 | 8 | 6 | 144 |
| | 98 | | | 3,217 |

1/ 3 shifts.

Recapitulation on weekly basis, production 6,800 tons

| Class | Number of man-shifts | Total man-hours | Tons per man per shift | Man-hour per ton |
|---|---|---|---|---|
| Bank drilling and shooting... | 20 | 140 | 340 | 0.021 |
| Stripping..... | 70 | 504 | 97.1 | .074 |
| Loading..... | 84 | 588 | 80.9 | .087 |
| Haulage..... | 75 | 525 | 90.6 | .077 |
| Tipple..... | 84 | 588 | 80.9 | .086 |
| Miscellaneous..... | 112 | 796 | 60.7 | .117 |
| Supervision..... | 10 | 76 | 680 | .011 |
| | 455 | 3,217 | 14.9 | .473 |



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## Mine 13

The thickness of the coal mined in this operation averages 50 inches. The overburden consists of surface soil, clay, and at some places sandstone and 12 to 30 feet of hard shale. The thickness ranges from 12 to 15 feet, where the mine was opened with a box cut, to an average of 44 feet at the time the property was visited.

### Drilling and Blasting Overburden

The bank had formerly been drilled horizontally with an electrically driven auger-type drill, but a vertical drill of the same type is being tried. This auger-type drill bores a 3½-inch-diameter hole. The holes are usually spaced on 24-foot centers and staggered, rows being 21 feet apart. Holes are drilled to within 18 to 24 inches of the top of the coal, and from 8 to 10 holes 35 to 40 feet deep are drilled in 7 hours. The drill is moved with a tractor.

Usually two rows of vertical holes are shot at one time. When the thickness of the overburden is approximately 45 feet, the holes are sprung with 75 pounds of 2½- by 16-inch, 30-percent gelatin dynamite. The hole is then charged with approximately 400 pounds of FF or FFF black powder and shot with a No. 6 electric squib placed in one stick of 30-percent gelatin dynamite. If the overburden averages 38 feet, the holes are sprung with approximately 50 pounds of 30-percent gelatin dynamite and then charged with 300 pounds of black powder. The shots are fired as in the deeper holes. Two men charge and fire all holes.

Where horizontal holes are used, they are drilled from 18 to 24 inches above the coal in the blue shale with an auger-type drill. They are 4-1/8 inches in diameter and usually 50 feet deep. These holes are not sprung but are charged with 3½-inch-diameter by 16-inch, 30- or 40-percent gelatin dynamite and fired with an electric detonator.

### Uncovering Coal

The overburden is removed with an electrically operated shovel equipped with a 95-foot boom, 58-foot dipper stick, and 12½-cubic-yard dipper. The width of the shovel cut usually is 50 feet and the distance from high wall to spoil bank is 64 feet. The stripping shovel operates three 8-hour shifts per day and removes from 12,000 to 16,000 cubic yards of overburden in 24 hours. The crew of the stripping shovel consists of an operator, oiler, and groundman for each shift. On an average, the shovel operates 80 percent of the working time. The length of the pit is approximately 1½ miles. The surface of the coal is cleaned with a tractor-operated bulldozer. The coal is washed, and careful cleaning in the mine is not necessary.



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## Coal Loading

At times the coal is shot before loading. Holes are drilled with a jackhammer-type pneumatic drill and charged with half a stick of 1½- by 8-inch pellet powder. Spacing between holes is governed by the character of the coal demanded - close spacing for small sizes and wider spacing for large sizes.

The loading shovel is electrically operated and is equipped with a 2¾-cubic-yard dipper. The coal is removed from a cut 50 feet wide and is loaded into trucks that operate on the 14-foot coal berm. The rear of the truck is loaded first and swings of the loaded dipper are toward the cab, but, as a safety measure, they do not pass over the cab.

The loading crew consists of an operator and three groundmen, who work a 7-hour shift. An average of 2,500 tons of raw coal is loaded per shift.

## Haulage

Truck haulage is used from loading face to tipple. The main road, which averages 40 feet in width, is constructed outside the coal area. Before the plant was put in operation, the main road was located, surface drainage ditches were cut, and the subbase was built of 2 to 3 feet of crushed limestone. This was then surfaced with 3 to 4 inches of gravel. Since the plant has been in operation, extensions have been made to the main road in advance of present needs. Drainage ditches have been dug and the subbase constructed of tipple refuse. This is allowed to weather and settle and, when the road is needed, it will be leveled and surfaced. This road is practically level. Lateral roads are run into the pit from the main road at approximately ¼-mile intervals. Openings are left in the spoil pile for these laterals, and the coal is left for each runway.

Trucks enter the pit on the roadway back of the loading shovel and after loading leave the pit on the roadway ahead of the shovel. In this way trucks do not pass in the pit. The loading shovel cuts out at each roadway and, after passing over, digs in again. The roadway is usually approximately 14 feet wide.

Five trucks are used, each having a 15-ton, automatic, drop-bottom trailer.

## Drainage

Surface water is ditched around the working pit, but water that enters the pit at lateral roadways following rainfall and other water that accumulates in the mine is gathered in sumps and discharged to the surface by electrically driven pumps mounted on wheels.



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## Preparation

Coal is dumped from trucks into a hopper at the tipple. This hopper is constructed of steel and concrete and has a capacity of 75 tons. From the hopper the coal is conveyed to the shaking screens in the tipple for sizing. The minus 3-inch coal is conveyed to the washer for treatment. The capacity of the tipple and washer is 400 tons and 200 tons per hour, respectively. The tipple is also equipped with picking tables, four loading booms, and seven loading tracks. The refuse from the tipple, which averages 250 tons per day, is transported by two 3-ton trucks and deposited on the extension of the main haulage road.

## Power

Electric power, which is purchased from a public utility company, is 33,000-volts, 3-phase, 60-cycle alternating current. The main power line is built outside the estimated limit of stripping, and laterals are built toward the workings from this main transmission line. Spacing between laterals is usually 900 feet. Current is stepped down with transformers from 33,000 to 4,700 volts for use on the stripping shovel and to 2,300 and 440 volts for loading shovel, drills, and other equipment. The trailing cables on the electrical units are usually 1,000 feet long.

## Summary

Shovel data (see tables 2 and 3).

| | |
|---|---|
| Average overburden stripped per hour.....cubic yards | 510 |
| Average raw coal uncovered per hour.....tons | 72 |
| Ratio of digging time to operating time.....percent | 80 |
| Average clean coal loaded per hour.....tons | 315 |
| Average daily production of clean coal.....do. | 2,200 |



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Mine employees, based on production of 2,200 tons per working day

| Class | Number of men | Hours worked per day | Days worked per week | Total man-hours per week |
|---|---|---|---|---|
| Drillers and helpers | 5 | 8 | 6 | 240 |
| Shooters | 2 | 7 | 6 | 84 |
| Stripping shovel: | | | | |
| Operator 1 x 3 [1] | | | | |
| Oiler 1 x 3 | 9 | 8 | 7 | 504 |
| Groundman 1 x 3 | | | | |
| Coal cleaning and shooting | 2 | 7 | 5 | 70 |
| Loading shovel: | | | | |
| Operator 1 | 4 | 7 | 5 | 140 |
| Groundmen 3 | | | | |
| Truck operators | 5 | 7 | 5 | 175 |
| Tipple and washer | 27 | 7 | 5 | 945 |
| Miscellaneous: | | | | |
| Carpenter 1 | | | | |
| Mechanic 1 | | | | |
| Tractor man 1 | | | | |
| Shopman 1 | 9 | 7 | 5 | 315 |
| Refuse haulers 2 | | | | |
| Pumpmen 2 | | | | |
| Watchman 1 | | | | |
| Monthly men | 7 | 8 | 6 | 336 |
| Supervision | 3 | 8 | 6 | 144 |
| | 73 | | | 2,953 |

1/ 3 shifts.

Recapitulation on weekly basis, production 11,000 tons

| Class | Number man-shifts | Total man-hours | Tons per man per shift | Man-hour per ton |
|---|---|---|---|---|
| Bank drilling and shooting | 42 | 324 | 261.9 | 0.029 |
| Stripping | 63 | 504 | 174.6 | .046 |
| Loading | 30 | 210 | 366.7 | .019 |
| Haulage | 35 | 245 | 314.3 | .022 |
| Tipple | 135 | 945 | 81.4 | .086 |
| Miscellaneous | 77 | 581 | 142.9 | .053 |
| Supervision | 18 | 144 | 611.1 | .013 |
| | 400 | 2,953 | 27.5 | .268 |

## Mine 14

The coal averages 30 inches in thickness, and usually the minable areas are not connected. The overburden varies in thickness and character. An average section is as follows:



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| | Feet | Inches |
|---|---|---|
| Surface soil | 4 | ..... |
| Hard shale (soapstone) | 12 | 6 |
| Gray shale | 22 | 6 |
| Coal | 2 | 6 |
| Fireclay | .... | ..... |

This mine consists of two sections, and coal is loaded from one section on the day shift and from the other at night.

## Drilling and Blasting Overburden

All drilling is done with horizontal, auger-type drills. Two drills are operated, one in each unit. One drill is electrically operated and drills holes 3 inches in diameter and 60 feet in depth. The other drill is driven by a gasoline motor and drills 6-inch-diameter holes, also 60 feet deep. Holes are spaced 33 feet apart in both sections and are drilled about 6 feet above the coal. From 8 to 10 holes are drilled by each drill in a 7-hour shift.

The 6-inch holes are charged with approximately 200 pounds of 5- by 16-inch, 40-percent dynamite and fired with an electric detonator. The 3-inch holes are sprung with 12½ to 25 pounds of 40-percent dynamite and usually are charged with 150 pounds of 4F black powder. Approximately 35 cubic yards of overburden are shot per pound of explosive.

## Uncovering Coal

The following stripping units are in use at this operation:

Section

1. Electrically operated shovel equipped with a 95-foot boom, 58-foot dipper stick, and 13-cubic-yard dipper.
2. Electrically operated shovel equipped with a 92-foot boom, 60-foot dipper stick, and 20-cubic-yard dipper.

Stripping is carried on continuously in both sections.

Cuts usually are made 65 feet wide at the mine having the smaller capacity shovel and 70 feet wide at the other unit. Approximately 15,000 cubic yards of overburden are moved per day by no. 1 unit and 24,000 cubic yards are stripped in 24 hours by the no. 2 unit.

A tractor-operated bulldozer is used to clean the surface of the coal after the stripping shovel has passed.



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## Coal Loading

During the winter season, a channeling machine is used to shear the coal first along the center of the cut, which in the case of a 70-foot pit would be 35 feet from the high wall, and again approximately 5 feet from the high wall. This makes a clean edge for the berm on which the trucks operate and leaves a straight edge along the spoil pile, which increases recovery.

Coal is loaded first from the half of the cut nearest the spoil pile and is drilled with a jackhammer using a 2¼-inch detachable bit. Approximately 25 holes, or 62½ feet, are drilled with a new detachable bit. The bits are sharpened and treated, after which 75 holes, or 187½ feet, are drilled - a total bit life of 250 feet before discarding. Three holes generally are used for a 35-foot coal face and each is charged with one-half to one stick of 1¾- by 8-inch pellet powder and fired electrically.

When the coal is being loaded from the cut nearest the spoil pile the trucks operate on the coal berm, and when loading the second cut they travel on the fire-clay bottom of the first cut. At unit 2 there is approximately 6 inches of jack rock on top of the fire clay.

There is one loading shovel in each section of the mine, as follows:

Section

1. An electrically operated shovel equipped with a 2¾-cubic-yard dipper. This shovel is of the horizontal-thrust type, and the dipper is pushed horizontally under the coal. (See fig. 9.)
2. An electrically operated shovel equipped with a 5-cubic yard coal-loading dipper. (See fig. 9.)

Both shovels are mounted on caterpillar crawlers.

Approximately 1,600 and 2,600 tons of raw coal is loaded at units 1 and 2, respectively.

## Haulage

Truck haulage is used from the coal face at both units to a central car-loading station. At this station the coal is dumped into a 50-ton hopper and fed to a 42-inch rubber belt 140 feet long and conveyed up to a loading boom, which passes the coal into standard-gage railroad cars. The capacity of the conveying belt is 600 tons per hour. Switching of the railroad cars at the loading station is done with a 42-ton standard-gage locomotive. The crew at this car-loading station consists of an operator, oiler, locomotive engineer, brakeman, and truck dumper.

As a rule, coal is loaded from one section on the day shift and from the other on the night shift.



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Haulage from the larger section is done with eight trailer trucks, six of which are employed in the smaller section on the night shift. These trailers vary in capacity from 13 to 17 tons. The truck haul averages 1½ miles one way, and the rail haul from the central car-loading station to the tipple, which is done by a railroad company, is 3½ miles. A sufficient tonnage is hauled to the tipple and placed on storage tracks to operate the preparation plant two shifts per day.

Each truck averages 25 trips per day from face to dumping station.

Main haulage roads are built outside the area to be mined, and laterals are constructed into the mines at intervals of approximately 1,000 feet. The crown of the main roads is usually 30 feet wide; tipple refuse is used for the subbase, which is surfaced with gravel and then oil treated. A tractor-operated road maintainer is used to keep the roads in good condition.

## Drainage

A small dragline operated by two men is used for digging surface drainage ditches. Electrically operated pumps are used in the pits where needed.

## Preparation

The coal is dumped from railroad cars into a hopper at the tipple and conveyed to shaking screens for sizing and hand cleaning. The 3-inch to ¼-inch sizes are sent to the washer for further treatment and preparation. The tipple is equipped with picking tables and loading booms. Refuse from the tipple and washer is hauled in trucks to old pits for disposal.

## Power

Electric power is purchased from a public utility company, and is 33,000 volts, 3-phase, 60-cycle alternating current. The stripping shovels are equipped with trailing cables 1,000 feet long, the trailing cables from the loading shovels being 1,500 feet long.

## Summary

Shovel data (see tables 2 and 3).

| | |
|---|---|
| Average overburden per pound of explosive.....cubic yards | 35 |
| Average stripped per hour, both sections.....do. | 1,625 |
| Average raw coal uncovered per hour, both sections.....tons | 140 |
| Average clean coal loaded per hour, Section 1.....do. | 207 |
| Average clean coal loaded per hour, Section 2.....do. | 336 |
| Average daily production clean coal.....do. | 3,800 |



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Employees, based on production of 3,800 tons per day (2 sections)

| Class | Number of men | Hours worked per day | Days worked per week | Total man-hours per week |
|---|---|---|---|---|
| Drillers | 2 | 7 | 5 | 70 |
| Helpers | 2 | 7 | 5 | 70 |
| Shooters | 2 | 7 | 5 | 70 |
| Shooter helper | 1 | 7 | 5 | 35 |
| Stripping shovels: | | | | |
| 13-cubic yard shovel: | | | | |
| Operator 1 x 3 [1] | | | | |
| Oiler 1 x 3 | 9 | 8 | 7 | 504 |
| Groundmen 1 x 3 | | | | |
| 20-cubic yard shovel: | | | | |
| Operator 1 x 3 [1] | | | | |
| Oiler 1 x 3 | 12 | 8 | 7 | 672 |
| Groundmen 2 x 3 | | | | |
| Loading shovels: | | | | |
| Operators 1 x 2 [2] | | | | |
| Oilers 1 x 2 | 8 | 7 | 5 | 280 |
| Pitmen 2 x 2 | | | | |
| Cleaning and shooting coal and face preparation | 16 | 7 | 5 | 560 |
| Truck operators | 14 | 7 | 5 | 490 |
| Road maintenance | 2 | 7 | 5 | 70 |
| Truck maintenance | 3 | 7 | 5 | 105 |
| Central dumping station | 10 | 7 | 5 | 350 |
| Main line railroad [3] | 4 | 8 | 5 | 160 |
| Tipple and washer: | | | | |
| Locomotive crew | 2 | 7 | 5 | 70 |
| Railroad car dumpers | 8 | 7 | 5 | 280 |
| Miscellaneous | 37 | 7 | 5 | 1,295 |
| Refuse haulers | 4 | 7 | 5 | 140 |
| Miscellaneous | 4 | 7 | 5 | 140 |
| Mechanics, electricians, blacksmiths, etc. | 15 | 7 | 5 | 525 |
| Monthly men | 4 | 8 | 6 | 192 |
| Supervision | 5 | 8 | 6 | 240 |
| | 164 | | | 6,318 |

1/ 3 shifts.
2/ 2 shifts.
3/ Hauled by railroad company at fixed charge per car.



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Recapitulation on weekly basis, production 19,000 tons

| Class | Number man-shifts | Total man-hours | Tons per man per shift | Man-hour per ton |
|---|---|---|---|---|
| Bank drilling and shooting.... | 35 | 245 | 542.8 | 0.013 |
| Stripping..... | 147 | 1,176 | 129.2 | .062 |
| Loading..... | 120 | 840 | 158.3 | .044 |
| Haulage..... | 165 | 1,175 | 115.1 | .062 |
| Tipple..... | 255 | 1,785 | 74.5 | .093 |
| Miscellaneous..... | 119 | 857 | 159.6 | .045 |
| Supervision..... | 30 | 240 | 633.3 | .013 |
| | 871 | 6,318 | 21.8 | .332 |

In certain classes of operation, where the required working hours exceed the maximum set out in the contract with the Mine Workers, additional men are called out as needed.

## Mine 15

The coal seam mined at this property averages 17 inches in thickness. It is very hard but free from partings and clay veins. The overburden averages 30 feet in thickness. A section is as follows:

| | Feet | Inches |
|---|---|---|
| Soil and clay..... | 12 | ..... |
| Hard blue shale..... | 15 | ..... |
| Hard black shale..... | 2 | ..... |
| Coal..... | 1 | 5 |
| Limestone..... | .... | ..... |

### Bank Drilling and Blasting

The surface soil and clay, which occurs above the hard blue shale, is removed without blasting by a dragline excavator. The remaining overburden is drilled vertically with a jackhammer-type pneumatic drill, using detachable bits. Holes are approximately 14 feet deep and they are started with a $2\frac{1}{4}$-inch-diameter bit and finished with a $1\frac{3}{4}$-inch bit. The holes are spaced on 30-foot centers and staggered. Each hole is sprung with from 9 to 11 sticks of 40-percent dynamite and then charged with one 25-pound keg of black powder. All charges are fired electrically. No data are available on the quantity of overburden shot per pound of explosive.

### Uncovering Coal

The stripping property is approximately 1 mile long, and a dual system is used in removing the overburden. The stripping units are:



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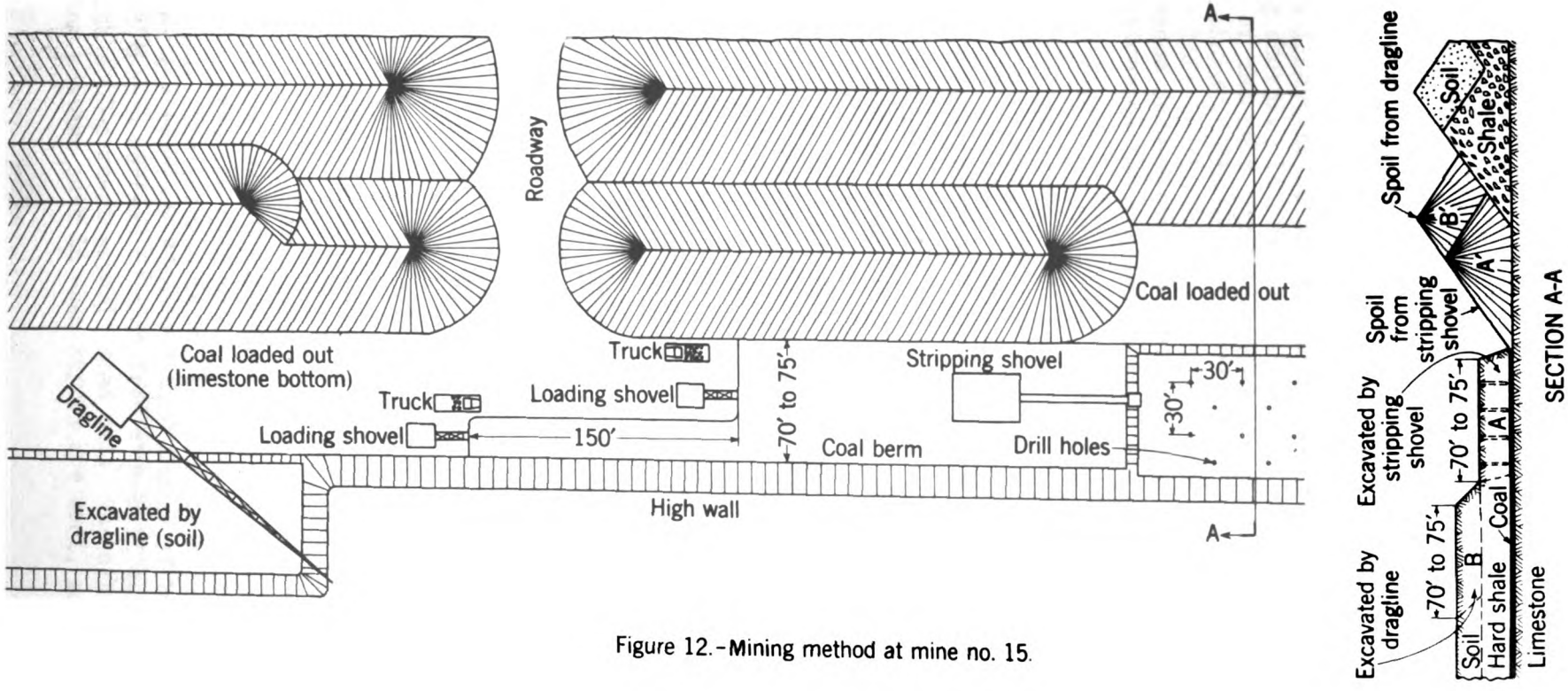


Figure 12.–Mining method at mine no. 15.

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1. A steam-operated, full-revolving-type shovel mounted on crawlers (caterpillars) equipped with an 80-foot boom, 58-foot dipper stick, and 6-cubic-yard dipper.
2. An electrically operated dragline, wheel mounted on rails and equipped with a 125-foot boom and 6-cubic-yard dipper.

Both the dragline and the shovel make a cut 70 to 75 feet wide. The dragline works on the limestone bottom in the cut behind both the coal loaders and the stripping shovel. It removes the surface soil and clay, which is the top portion of the next cut to be made, and deposits the spoil back of that cast by the shovel. The shovel removes the lower portion of the overburden, which was left by the dragline in the previous cut and deposits the spoil in the space from which the coal has been removed. Figure 12 shows the working positions of the various units in the system used in this mine.

As a rule, the dragline is operated three 8-hour shifts per day and the stripping shovel two 8-hour shifts.

The surface of the coal is cleaned with a Fresno scraper and steel brooms.

## Coal Loading

The coal is hard, and it is necessary to blast it before loading. Holes are drilled on 3- to 4-foot centers with a jackhammer charged with pellet powder and are fired electrically.

Two steam-operated, horizontal, thrust-type, coal-loading shovels are used. They are equipped with 1½-cubic-yard dippers. These shovels are operated in tandem. (See fig. 12.) The head shovel removes the coal from approximately two-thirds of the width of the pit, and the rear loader loads the remaining third. The distance between loaders is about 150 feet. The coal is loaded into trucks. The head shovel is the principal loader, and the second shovel begins to load the truck that would be standing idle waiting for the first shovel to complete loading its truck. As soon as a truck is filled at the head shovel, the truck at the rear shovel moves to the first shovel to complete loading. In this way no time is lost waiting for the loading shovel. The head shovel loads approximately twice the tonnage of the second shovel. An average of 1,100 tons is loaded by both shovels in seven hours.

## Haulage

Trucks and trailers are used from loading shovels to tipple. The main haulage road is built outside the coal area being mined. It is graded 35 feet wide and well drained. The subbase is built of tipple refuse 12 to 18 inches thick. On top of the tipple refuse is 3 to 4 inches of burned shale from mine dumps, and then a surface of chat from zinc-mill tailings. The surface is treated with a 60-percent asphalt road oil. The oil is placed on the road before freezing weather sets in when nights are cool, so that the



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oil will set properly. As the surface of the road is worn down by the trucks, the road is not scorified, but another layer of chat is added and this treated with oil. The surface of the road is not disturbed. This method of road maintenance has proved very satisfactory at this operation. The length of haul is approximately 2 miles one way. Lateral roads are built into the working cuts at varying intervals, usually 900 or 1,000 feet, and, if possible, trucks enter the pit at one lateral and leave by another, making a circle haul.

Seven drop-bottom-type truck-trailer units are in use - two 6½-ton, four 12-ton, and one 20-ton. A truck and trailer average 16 trips in one shift. The speed of the trucks is balanced to keep a steady supply of coal passing from the mine to the tipple.

## Drainage

Ditches are dug on the surface to divert water from the pit, but during rains water enters the mine over and around the lateral roads. This is discharged by electric pumps.

## Preparation

The coal is dumped from the trucks into a hopper at the tipple and is conveyed to shaking screens for sizing and preparation on picking tables and loading booms. The tipple is equipped with three loading tracks and another is to be added.

## Power

Electric power, where used, is purchased from a public utility company; it is 3-phase, 60-cycle alternating current.

## Summary

Shovel data (see tables 2 and 3).

| | |
|---|---|
| Average overburden stripped per hour.....cubic yards | 390 |
| Average coal uncovered per hour.....tons | 20 |
| Average coal loaded per hour.....do. | 157 |
| Average daily production.....do. | 1,100 |



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Mine employees, based on production of 1,100 tons per working day

| Class | Number of men | Hours worked per day | Days worked per week | Total man-hours per week |
|---|---|---|---|---|
| Drilling and shooting..... | 2 | 7 | 7 | 98 |
| Stripping shovel: Operator 1 x 2 [1] / Oiler 1 x 2 / Foreman 2 x 2 / Groundmen 2 x 2 ..... | 12 | 8 | 7 | 672 |
| Dragline: Operator 1 x 3 [2] / Oiler 1 x 3 / Groundmen 1 x 3 ..... | 9 | 8 | 7 | 504 |
| Loading shovels: Engineers 2 x 1 [3] / Firemen 2 x 1 [3] / Groundmen 4 x 2 [1] ..... | 12 | 7 | 3 | 252 |
| Coal drilling, shooting and cleaning..... | 5 | 7 | 3 | 105 |
| Truck operators..... | 7 | 7 | 3 | 147 |
| Truck spotter..... | 1 | 7 | 3 | 21 |
| Tipple..... | 13 | 7 | 3 | 273 |
| Mechanic..... | 1 | 7 | 5 | 35 |
| Watchman..... | 1 | 7 | 7 | 49 |
| Monthly men..... | 2 | 8 | 6 | 96 |
| Supervision..... | 2 | 8 | 6 | 96 |
| | 67 | | | 2,348 |

1/ 2 shifts.
2/ 3 shifts.
3/ 1 shift.

Recapitulation on weekly basis, production 3,300 tons

| Class | Number of man-shifts | Total man-hours | Tons per man per shift | Man-hour per ton |
|---|---|---|---|---|
| Bank drilling and shooting... | 14 | 98 | 235.6 | 0.030 |
| Stripping..... | 147 | 1,176 | 22.4 | .356 |
| Loading..... | 51 | 357 | 64.7 | .108 |
| Haulage..... | 24 | 168 | 137.5 | .051 |
| Tipple..... | 39 | 273 | 84.6 | .083 |
| Miscellaneous..... | 24 | 180 | 137.5 | .055 |
| Supervision..... | 12 | 96 | 275 | .029 |
| | 311 | 2,348 | 10.6 | .712 |

Mine 16

The country in which this mine is situated is comparatively level. The coal averages 36 inches in thickness, and the overburden varies in thickness and character. A section is as follows:



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| | Feet |
|---|---|
| Surface soil | ..... |
| Yellow clay | 0 to 14 |
| Sandy shale | 6 to 8 |
| Limestone | 0 to 6 |
| Hard black shale | 0 to 5 |
| Coal | 3 |

Where the stratum of shale above the limestone is thin, the yellow clay stratum usually is thick. The bottom is fireclay.

## Drilling and Blasting Overburden

The overburden is drilled from the surface with two electric and one gasoline-operated well-type drills. Holes are spaced on 22-foot centers, and the rows are approximately 20 feet apart. The diameter of the holes is 6 inches, and they are drilled to approximately 1½ feet below the limestone. Three to four holes are drilled per shift by each drill.

The holes are not chambered but are charged with 40-percent dynamite. The amount of explosive, as a rule, is 15 pounds per foot of limestone plus 12 to 15 pounds for loosening the shale and clay materials. Only one primer is used, and the charge is detonated electrically. Usually two rows, comprising 10 to 18 holes, are shot at one time.

## Uncovering Coal

This operation consists of two units - a small one using steam equipment and another having an electrically operated stripping shovel. Only the latter operation will be described.

Figure 13 is a plan of this operation.

The stripping shovel is of the full-revolving type, mounted on crawlers, and has a 95-foot boom, a 64-foot dipper stick, and an 18-cubic-yard dipper. The distance from high wall to spoil bank usually is 75 feet. The shovel removes a cut 50 feet wide, depositing the spoil in the space from which the coal has been removed, usually 50 feet wide. The slope of the high wall bank averages 60° from the horizontal. The surface of the coal is very irregular. Grades of 12° to 14° are not uncommon. The stripping shovel usually advances down these grades 6 to 8 feet at a move but in passing up the other side of the dip is able to advance 10 to 12 feet at a time. The deck of the shovel is kept level along the axis at right angles to the cut but not along the axis parallel to the cut. This stripping shovel removes approximately 1,066 cubic yards of overburden an hour and uncovers 82 tons of coal net working time. The present mine is approximately 4,000 feet long.

The surface of the coal is cleaned with a tractor-operated bulldozer and afterward is swept with wire brushes and cleaned with compressed air.



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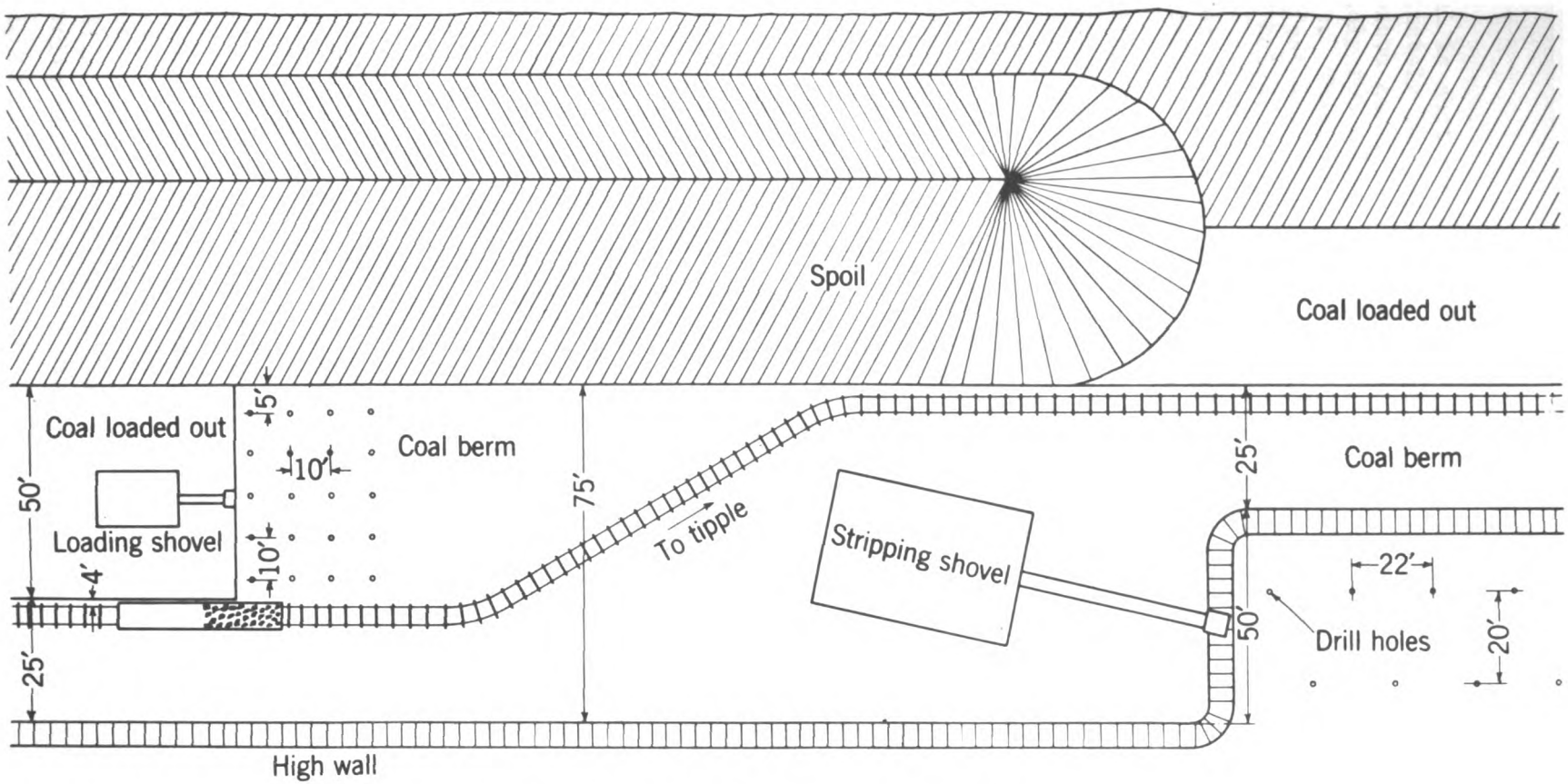


Figure 13.–Mining method at mine no. 16.

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## Coal Loading

The coal is shot before loading. Holes are drilled with a jackhammer on approximately 10-foot centers. (See fig. 13.) Six-point detachable bits, 1-5/8-inch gage, having a center hole, are used for drilling the coal. Approximately 200 holes, or 600 feet, is drilled before it is necessary to regrind the bit. These bits usually are reground twice, and approximately 100 holes or 300 feet are drilled after each regrind. The life of a bit is approximately 400 holes, or 1,200 feet of drilling.

The holes are charged with ½ to 1½ sticks of 25-percent dynamite and fired electrically.

The loading shovel, which is electrically operated, has a dipper of 3 cubic yards capacity. This shovel removes the coal from a cut 50 feet wide. (See fig. 13.) Approximately twenty-six 70-ton cars are loaded in a 7-hour shift.

## Haulage

The track is standard gage (4 feet 8½ inches) and is constructed of 90-pound rails on wooden ties. It is placed on the coal approximately 50 feet from the spoil bank and adjacent to the loading shovel (See fig. 13.) The loading shovel advances approximately 300 to 350 feet per shift. A crew of four track men usually shifts and lines 200 feet of track per shift. Two crews of four men each are used for track shifting, lining, and maintenance.

Standard drop-bottom railroad cars are used, and these are hauled in trips of three by 50-ton geared-type locomotives.

## Drainage

Surface water is diverted from the mine by ditches. Water that may accumulate in the mine is gathered in sumps and pumped to the surface with electric pumps.

## Preparation

The coal is dumped from railroad cars into a hopper at the tipple and conveyed to shaking and vibrating screens for sizing, which is done according to demand. The tipple is equipped with picking tables and loading booms and has eight loading tracks.

## Power

Electric power is purchased from a public utility company. It is 33,000-volt, 3-phase, 60-cycle, alternating current. Transformers step down this current to 4,400 volts for use on the stripping shovel and to 2,300 volts for use on the loading shovel. Electric motors on pumps, drills, and other equipment use 440 volts alternating current. Ground cables are used for power



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distribution. Average power consumption is 365,000 to 370,000 kw.-hr. per month. The stripping shovel uses approximately 80 percent of the total power consumed.

Summary

Shovel data (see tables 2 and 3).

| | |
|---|---|
| Average overburden stripped per hour actual working time..cubic yards | 1,066 |
| Average coal uncovered per hour actual working time.....tons | 82 |
| Ratio digging time to operating time.....percent | 81 |
| Average coal loaded per hour.....tons | 260 |
| Average daily production this unit.....do. | 1,820 |

Mine employees, based on production of 1,800 tons per working day (unit having electric stripping shovel)

| Class | Number of men | Hours worked per day | Days worked per week | Total man-hours per week |
|---|---|---|---|---|
| Drillers<br>Helpers<br>Shooters | 12 | 7 | 5 | 420 |
| Stripping shovel:<br>Engineers 1 x 3 [1]<br>Oilers 1 x 3<br>Groundmen 2 x 3 | 12 | 8 | 6 | 576 |
| Loading shovel:<br>Operator 1<br>Groundmen 2 | 3 | 7 | 5 | 105 |
| Cleaning coal<br>Shooting coal | 7 | 7 | 5 | 245 |
| Locomotive engineers 3 x 1<br>Locomotive firemen 3 x 1<br>Brakemen 3 x 1 | 9 | 7 | 5 | 315 |
| Trackmen | 8 | 7 | 5 | 280 |
| Tipple | 25 | 7 | 5 | 875 |
| Mechanics | 2 | 7 | 6 | 84 |
| Miscellaneous | 4 | 7 | 5 | 140 |
| Mine foreman | 1 | 7 | 6 | 42 |
| Superintendent | 1 | 8 | 6 | 48 |
| | 84 | | | 3,130 |

1/ 3 shifts.



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Recapitulation on weekly basis, production 9,000 tons

| Class | Number of man-shifts | Total man-hours | Tons per man per shift | Man-hour per ton |
|---|---|---|---|---|
| Bank drilling and shooting... | 60 | 420 | 150 | 0.047 |
| Stripping..... | 72 | 576 | 125 | .064 |
| Loading..... | 50 | 350 | 180 | .039 |
| Haulage..... | 85 | 595 | 105.8 | .066 |
| Tipple..... | 120 | 840 | 75 | .093 |
| Miscellaneous..... | 32 | 224 | 281.2 | .025 |
| Supervision..... | 17 | 125 | 529.4 | .014 |
| | 436 | 3,130 | 20.6 | .348 |

Wage rates and working conditions are governed by contracts between the operator and the United Mine Workers of America.

## Mine 17

The surface at this property is comparatively level. The thickness of the coal varies from 22 to 24 inches. There are many small slips throughout the seam. At some places there are local dips, but as a rule the seam follows the regional dip to the northwest. The overburden averages 20 feet in thickness, but as the workings progress to the west the thickness increases and a depth of 45 feet is considered maximum stripping at this mine. A section of the overburden is as follows:

| | Feet | Inches |
|---|---|---|
| Surface soil and clay..... | 8 | ..... |
| Black laminated shale..... | 10 | ..... |
| Hard black sandy shale (cap rock) | 2 | 6 |
| Coal..... | 2 | ..... |
| Fireclay..... | .... | ..... |

### Drilling and Blasting Overburden

Generally all of the overburden except the cap rock can be dug with the stripping shovel without blasting. If, however, the black laminated shale becomes a hard gray shale, then all of the overburden must be drilled and blasted.

The cap rock is drilled vertically with a jackhammer. The spacing of the holes across the cut varies with the thickness of the rock. The thinner the stratum, the closer the holes are spaced, since less explosive can be used and smaller areas are broken. The holes are charged with varying amounts of explosive, but usually three or four sticks of 40-percent dynamite are used where the cap rock is 3 feet thick. The explosives are fired electrically.



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## Uncovering Coal

The stripping shovel is electrically operated and is equipped with an 87½-foot boom, 56-foot stick and a 15-cubic-yard dipper. This shovel makes a cut averaging 60 feet in width and usually removes the overburden above the cap rock, leaving a bench on which the drillers can work. (See fig. 7.) The stripping shovel operates on the coal berm ahead of the loading shovel. It operates three 8-hour shifts per day and removes an average of 415,000 cubic yards of overburden per month. The crew consists of an operator, oiler, and two ground men, who drill and shoot the cap rock if necessary.

## Coal Loading

The coal is drilled with a jackhammer. Holes are spaced on 7-foot centers, and each hole is charged with a ½ to ¾ stick of 1¾- by 8-inch pellet powder and fired electrically.

Loading is done from the full width of the pit, which is approximately 60 feet wide. The loading shovel, which is the horizontal thrust (skimmer) type, is electrically driven and is equipped with a 2¾-cubic-yard dipper. The coal is loaded into a 4-ton skip of an electrically operated derrick or bank machine. This derrick is equipped with a 71-foot boom. When the skip is loaded, it is raised and swung over the railroad car on the high wall and the coal is discharged. An average of 1,400 tons of raw coal is loaded per 7-hour shift.

## Haulage

A standard-gage track is on the high wall, and standard drop-bottom-type railroad cars having a capacity of approximately 58 tons are used. These cars are placed in trips of five cars opposite the bank machine and when loaded are hauled with a steam locomotive approximately 1 mile to a central yard. Two units are in use. From the central yard the coal is hauled in trains to the tipple and cleaning plant.

The track is maintained along the high wall for the length of the cut and is shifted the full width of a cut (approximately 60 feet) by a track crew using a tractor. The location of the next cut is staked, and the track is shifted to this new position ahead of the stripping shovel.

## Drainage

Drainage ditches are dug across the surface with a small dragline excavator. These ditches carry surface water away from the operation. Rain water that falls into the cut or drains in through the strata and spoil is discharged to the surface by electric pumps.



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## Preparation

The loaded railroad cars are brought from a storage yard at the tipple to the hopper with a small steam locomotive. There the coal is discharged into a 100-ton capacity hopper and conveyed to the tipple for sizing. The tipple, which has five loading tracks, is equipped with shaking screens, picking tables, and loading booms. The minus 3-inch coal is conveyed to the washer for further treatment. Various sizes of coal are prepared, according to demand.

## Power

Electric power, which is 3-phase, 60-cycle alternating current, is purchased from a public utility.

## Summary

Shovel data (see tables 2 and 3).

| | |
|---|---|
| Average overburden stripped per hour.....cubic yards | 590 |
| Average raw coal uncovered per hour.....tons | 42 |
| Ratio of digging time to working time.....percent | 80 |
| Average clean coal loaded per hour.....tons | 171 |
| Average daily production clean coal.....do. | 1,200 |

Mine employees, based on production of 1,200 tons per working day

| Class | Number of men | Hours worked per day | Days worked per week | Total man-hours per week |
|---|---|---|---|---|
| Bank drilling and shooting 1 x 3[1] | 3 | 8 | 7 | 168 |
| Stripping shovel: Operator 1 x 3[2] / Oiler 1 x 3 / Groundmen 1 x 3 | 9 | 8 | 7 | 504 |
| Loading shovel: Operator 1 / Groundmen 2 | 3 | 7 | 5 | 105 |
| Coal cleaning and shooting | 8 | 7 | 5 | 280 |
| Bank machine | 2 | 7 | 5 | 70 |
| Locomotive engineers | 2 | 7 | 5 | 70 |
| Trackmen | 14 | 7 | 5 | 490 |
| Tipple and washer | 34 | 7 | 5 | 1,190 |
| Miscellaneous | 10 | 7 | 5 | 350 |
| Monthly men | 3 | 8 | 6 | 144 |
| Supervision | 3 | 8 | 6 | 144 |
| | 91 | | | 3,515 |

1/ One ground man at stripping shovel charged to drilling and shooting cap rock.
2/ 3 shifts.



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Haulage from central loading yard to tipple is made by railroad company at a fixed charge per car, and the employees are not included in this table.

Recapitulation on weekly basis, production 6,000 tons

| Class | Number of man-shifts | Total man-hours | Tons per man per shift | Man-hour per ton |
|---|---|---|---|---|
| Bank drilling and shooting... | 21 | 168 | 285.7 | 0.028 |
| Stripping..... | 63 | 504 | 95.2 | .084 |
| Loading..... | 65 | 455 | 92.3 | .076 |
| Haulage..... | 80 | 560 | 75.0 | .093 |
| Tipple..... | 170 | 1,190 | 35.3 | .198 |
| Miscellaneous..... | 74 | 494 | 81.1 | .082 |
| Supervision..... | 24 | 144 | 250.0 | .024 |
| | 497 | 3,515 | 12.1 | .585 |

Mine 18

The coal at this mine averages 24 inches in thickness, and at the time the property was visited the thickness of the overburden was approximately 30 feet. The surface is comparatively level, and the coal dips approximately 25 feet to the mile to the northwest. There are, however, local dips. A section is as follows:

| | Feet | Inches |
|---|---|---|
| Surface soil and clay..... | 8 | ..... |
| Laminated gray-brown sandy shale. | 6 | ..... |
| Coal (not always present)..... | 1 | 2 |
| Blue shale..... | 10 | ..... |
| Hard black sandy shale (cap rock) | 4 | ..... |
| Coal..... | 2 | ..... |
| Fireclay..... | 1 | 6 |

The "cap rock" ranges in thickness from 3 to 36 inches. When it is less than a foot thick it causes some trouble, since it is difficult to shoot and must be loosened by the stripping shovel dipper.

Drilling and Blasting Overburden

Usually it is not necessary to loosen the overburden above the cap rock by blasting, but the cap rock is drilled and blasted. The overburden is removed from the cap rock for a distance of 10 feet, making a bench across the cut. The cap rock is then drilled with a jackhammer, the holes being spaced on 10-foot centers across the top of the cap rock. The holes are $1\frac{3}{4}$ inches in diameter and each is charged with approximately $\frac{1}{2}$ pound of FF black powder, tamped, and fired electrically. One row of holes is drilled and shot for each move of the shovel. When this method of drilling and shooting is



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not practical, due to increasing depth and hardness of the strata in the overburden, a horizontal-type drill is used, and the total thickness of overburden is shot. About 50 percent of the area requires bank shooting.

## Uncovering Coal

The stripping shovel is electrically operated and equipped with an 87-foot boom, 62-foot dipper stick, and 20-cubic-yard dipper. Cuts are made 70 to 75 feet wide, the distance from high wall to spoil bank. The length of the pit is approximately eight tenths mile. After the cap rock has been drilled and shot, it is removed by the shovel and deposited in the space from which the coal has been removed and at the edge of the berm. The shovel is then advanced 10 feet, and the material above the cap rock is deposited back of the spoil from the cap rock, which acts as a retaining wall. A bench is formed ahead of the shovel by the cap rock, and after the full width of the cut has been made the bench is shot and the first operation is repeated. Approximately 1,000 cubic yards of overburden is stripped per hour. The stripping shovel is operated three 8-hour shifts per day. During an 18-month period it averaged 625,000 cubic yards per month.

## Coal Loading

An electrically operated shovel with horizontal boom (thrust or skimmer type) equipped with a 4½-cubic-yard-capacity dipper is used to load the coal. The coal is drilled and shot before loading. Drill holes are spaced on 9-foot centers and staggered. They are drilled with a jackhammer-type pneumatic drill using a 2-inch detachable bit. The life of a bit is approximately 1,000 feet of drilling, after which it is discarded. The holes are charged with one stick of 1¾- by 8-inch pellet powder and fired electrically.

Coal is taken from the entire width of cut, 70 to 75 feet, and loaded into the aluminum skip of a derrick or elevator (bank machine). This machine, which is electrically operated, is equipped with an 80-foot boom, and the skip has a capacity of 10 tons. The skip is suspended from a wire cable and raised and lowered by an electric hoist. When the skip is loaded it is raised over the edge of the high wall and the coal is discharged into railroad cars placed on the track along the edge of the high wall. (See fig. 7.) The derrick is mounted on caterpillars, and the skip can be placed ahead of the loading shovel at any place in the cut.

## Haulage

Because of the level surface and the characteristics of the overburden, whereby it stands and does not cave, the haulage tracks are located on the surface near the high wall. (See fig. 7.) In this method of rail haulage it is not necessary to maintain the track on the coal berm in the cut or to dump the spoil over the track, and the track can be shifted more easily on the surface than in the mine.



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As the stripping shovel advances the cut along the high wall, the track is shifted the full width of the cut, 70 to 75 feet. This is done with a track crew and tractor. The track is shifted in sections of four rail lengths as a unit.

The track, which is standard gage (4 feet 8½ inches), is constructed with 60-pound rail on wooden ties. Standard railroad cars are used, and they are hauled in trips of three cars by a 35-ton gasoline locomotive. Two haulage units transport the cars to and from the loading point on the high wall to a main storage yard. At this yard trains are made up of 25 to 27 cars and hauled by a steam locomotive to the preparation plant.

## Drainage

Surface water is diverted from the working mine by ditches. Main ditches are dug across the area with a small drag-line excavator. Lateral ditches cross the property so as to divert surface water following rainfall to the main ditches. The water that accumulates in the cut is discharged to the surface by means of electrically operated pumps.

## Preparation

A railroad-car storage yard is at the tipple, and loaded cars are run by gravity, as needed, to a rotary dump. This dump rotates 180°, and one railroad car (averaging 53 tons capacity) is dumped at a time, discharging the coal into a hopper. The coal is fed from the hopper onto a conveyor by a reciprocating feeder and transported to the tipple. All coal over 6 inches is crushed and all coal is washed. Coal is sized over shaking screens according to demand and is loaded over loading booms into railroad cars.

## Power

All power is purchased from a public utility company and is 3-phase, 60-cycle alternating current. Voltage is stepped down by transformers to the voltage required by the various units. Trailing cables on the stripping shovel are 1,300 feet long, and transformers and switch boxes are advanced to conform to this length of cable. Power consumption is approximately 6.5 kw.-hr. per ton of coal produced.

## Summary

Shovel data (see tables 2 and 3).

| | |
|---|---|
| Average overburden per pound of explosive.....cubic yards | 30 |
| Average stripped per hour.....do. | 1,000 |
| Average raw coal uncovered per hour.....tons | 85 |
| Ratio of digging time to operating time.....percent | 80 |
| Average raw coal loaded per hour.....tons | 400 |
| Power consumption per ton of coal.....kw.-hr. | 6.5 |
| Average daily production clean coal.....tons | 2,400 |



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Mine employees, based on production of 2,400 tons per working day

| Class | Number of men | Hours worked per day | Days worked per week | Total man-hours per week |
|---|---|---|---|---|
| Drillers and shooters | 2 | 7 | 7 | 98 |
| Stripping shovel: Operator 1 x 3 1/, Oiler 1 x 3, Groundmen 2 x 3 | 12 | 8 | 7 | 672 |
| Loading shovel: Operator 1, Groundmen 4 | 5 | 7 | 3 | 105 |
| Coal drilling, shooting, and cleaning | 4 | 7 | 3 | 84 |
| Bank machine | 2 | 7 | 3 | 42 |
| Locomotive crews: | | | | |
| Mine | 2 | 7 | 3 | 42 |
| Main line | 4 | 8 | 3 | 96 |
| Trackmen | 22 | 7 | 3 | 462 |
| Tipple and washer | 28 | 7 | 3 | 588 |
| Shopmen | 2 | 7 | 5 | 70 |
| Miscellaneous | 3 | 7 | 5 | 105 |
| Monthly men | 5 | 8 | 6 | 240 |
| Supervision | 3 | 8 | 6 | 144 |
| | 94 | | | 2,748 |

1/ 3 shifts.

Recapitulation on weekly basis, production 7,200 tons

| Class | Number of man-shifts | Total man-hours | Tons per man per shift | Man-hour per ton |
|---|---|---|---|---|
| Bank drilling and shooting | 14 | 98 | 514.3 | 0.014 |
| Stripping | 84 | 672 | 85.7 | .093 |
| Loading | 33 | 231 | 218.2 | .032 |
| Haulage | 84 | 600 | 85.7 | .083 |
| Tipple | 84 | 588 | 85.7 | .082 |
| Miscellaneous | 55 | 415 | 130.9 | .058 |
| Supervision | 18 | 144 | 400.0 | .020 |
| | 372 | 2,748 | 19.4 | .382 |

SUMMARY

Recovery

The percentage of coal recovered from any tract of land by strip mining depends upon physical and economic conditions, some of which are as follows:



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1. Local dips in the coal, where the digging grades would be excessive: At some places the cost of removing the additional overburden in these dips is greater than the value of the coal that might be recovered, hence, where excessive grades into and out of local dips exist, the stripping shovel may pass over them and not dig down to the coal, and the coal in the dip is lost. This is especially true in thin seams.

2. At some places the spoil banks are of such character that they slide, especially when wet, and some coal is lost in small berms that are left at the edge of the spoil bank.

3. The thickness of the seam: In thick seams the loss of coal from the top of the seam and failure of the loading shovel to dig to the bottom will not reduce the percentage of coal recovered as much as in thin seams; that is, the percentage of recovery from thick seams is usually larger than from thin seams.

4. The presence of horsebacks or clay veins in an acreage will reduce the estimated recoverable coal tonnage due to the difficulties met in loading coal free from impurities. Recovery can be increased by loading both impurities and coal, if too difficult to separate in the strip mine, and washing the product. The experience at the mines described shows a recovery of 75 to 95 percent.

## Strip Mining as a Factor in Conservation of Natural Resources

1. Coal with poor roof and lying at depths up to 60 feet from surface, (in isolated cases 85 feet for short distances), has been stripped, which might not have been recovered by underground methods due to this roof condition.

2. Thin seams, 14 to 24 inches, that cannot be mined economically by underground methods are being stripped successfully. Areas containing seams, with reasonable depth of overburden, that cannot be mined economically with new equipment may be mined by using equipment that has been amortized on properties having thicker seams and thus counteract the higher mining costs by lower fixed charges. Thus, thin seams that could not be recovered otherwise may be mined by strip-mining methods.

3. There are areas in which the coal is of relatively poor quality, on account of which it must be sold at a reduced price, if at all. Underground mining therefore is not profitable. By strip mining with large-capacity equipment, however, it may be possible to mine such coal profitably. These areas therefore contain potential coal reserves.

4. A contraphase of conservation in strip mining is the destruction of agricultural land, which presents a serious problem in some regions. Reforesting of stripped land has been attempted with some success in certain areas, and this subject has been discussed briefly in Bureau of Mines Bulletin 293 (pp. 118-121), previously referred to.



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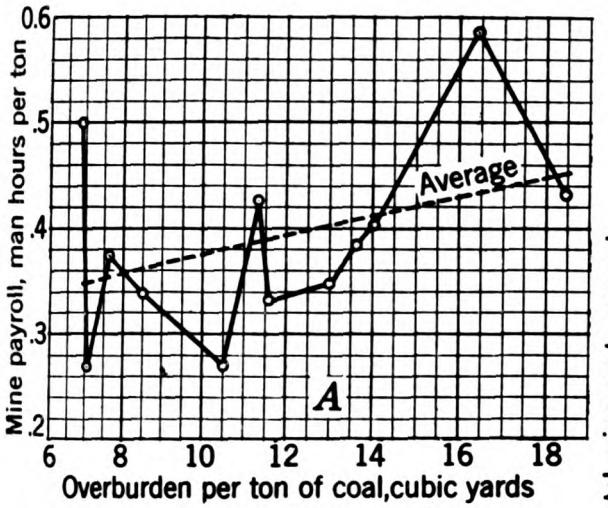
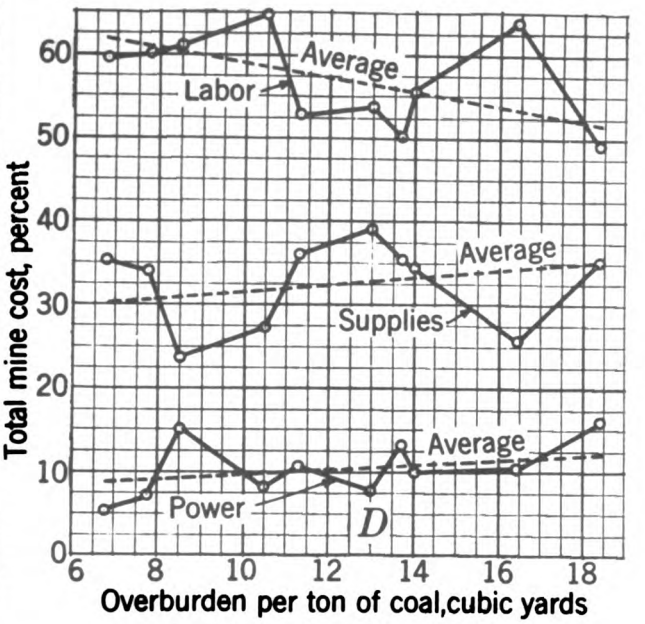
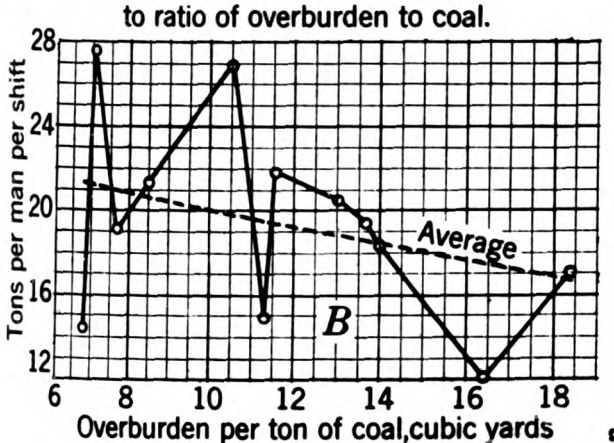


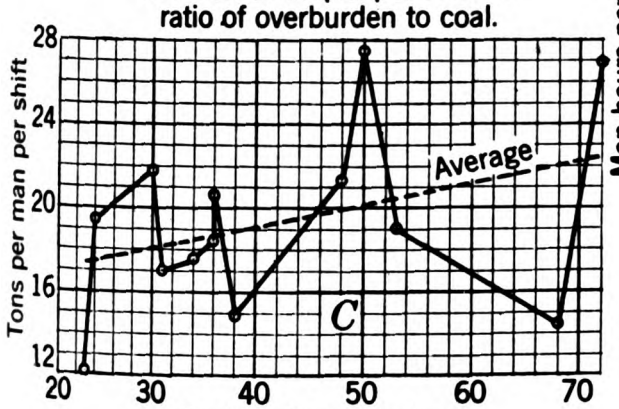

Relation of total mine labor to ratio of overburden to coal.



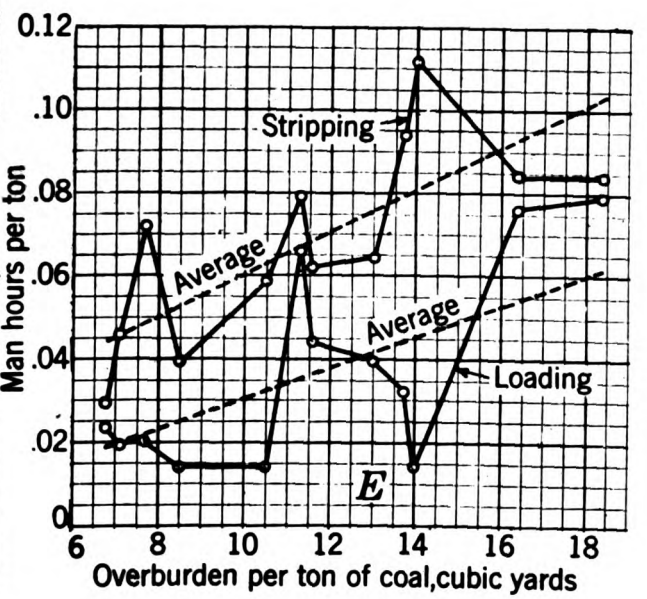

Relation of cost in percent to ratio of overburden to coal.




Relation of output per man to ratio of overburden to coal.




Relation of output per man to thickness of coal.




Relation of stripping and loading labor to ratio of overburden to coal.

Figure 14.- Significant relationships of different factors to overburden per ton of coal.

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## Explanation of Graphs

The graphs apply only to mines using electrically operated stripping equipment, since the steam-operated plants are few and decreasing in use. (See fig. 14.)

It should be kept in mind that mines with the same ratio of overburden to coal thickness are not comparable, unless the coal thickness and character of the overburden are approximately the same; that is, it may be more economical to mine a 2-foot seam of coal with 20 feet of overburden than to mine a 5-foot seam with 50 feet of overburden, yet the ratio is the same in both cases.

A. - This curve shows the average rate of increase in total mine man-hours per ton with increase in ratio of overburden to coal for 12 all-electric operations. It is noted that some of the points on the curve fall considerably off the average line. This emphasizes the influence of peculiar local conditions upon the labor cost of strip mining, particularly the characteristics of the overburden, the way it breaks, and the amount of drilling and blasting required.

The high point on the curve is at a mine where cleaning plant and tipple labor costs are out of line being over twice the average of those at the other mines.

Drilling, shooting, and maintenance labor costs appear out of line at the mine showing the next highest point (0.50 man-hour per ton). A study should be made and tests conducted on spacing of drill holes and shooting of the overburden with the object of obtaining better fragmentation, which should result in lowering these items.

B. - This curve emphasizes the same points as does curve A, but in different terms. High tons per man-shifts is equivalent to low man-hours per ton. The general trend of the average line of the curve is downward, since with increasing ratios of cubic yards of overburden to tons of coal more yardage must be handled for a given tonnage.

C. - This curve shows the trend in rate of increase in tons per man-shift as the thickness of the seam becomes greater.

The two points (coal thickness, 23 and 68 inches) that are farthest below the average line represent the same mines shown above the average line and explained under curve A.

The point (coal thickness, 50 inches) representing the mine having the greatest tons per man per shift indicates the influence of favorable physical and operating conditions.

D. - The percentages of labor, supplies, and power costs of the total mine cost, which includes all charges except depreciation, depletion,



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fixed, general, and selling expense, are plotted against the ratio of cubic yards of overburden to tons of coal. The percentage of labor cost of the total mine cost decreases with the increase in the ratio of overburden, while the percentage of supply and power costs increases with increased ratio of overburden to tons of coal. (The sum of the three items equals 100 percent.) This indicates that the proportionate costs of explosives and maintenance supplies become greater as the ratio increases. Power costs also increase, due to handling more overburden.

E. - The high point on the stripping curve shows the influence of irregular character of the overburden at this property, where there is a comparatively high ratio of overburden to coal. This mine also has the lowest point below the average on the loading curve, which shows the results of loading without cleaning the coal in the mine, minimum of haulage delays, and high daily production.

The high point above the average on the loading curve (0.066 man-hour per ton) indicates the influence of mining a coal seam that requires excessive cleaning, which is done in the mine before the coal is loaded.

## Trend in Equipment Changes

Until about 1926, the largest stripping shovels had a dipper capacity of 6 cubic yards. Usually they were mounted on railroad trucks and were moved over rails; most of them were operated with steam, but a few were operated electrically. Electricity had proven its superiority, both in economy of operation and flexibility. Under physical conditions existing at that time, mining operations on the whole were successful; but in some areas the thickness of overburden had reached a point where shovels of this size were unable to uncover the required average coal tonnage. Areas of coal that could be stripped with shovels of this type were being depleted rapidly, and the necessity for shovels of greater capacity was realized. From the experience gained in mining and in the design of shovels, larger sizes resulted. The development of shovels of larger dipper capacity and reach has been rapid, until now shovels of 30 and 32 cubic yards, capable of removing 60 to 65 feet of overburden, are in use. Dipper capacities in smaller shovels have been increased by the use of steel alloys and aluminum, which give greater capacity for the same weight.

The size of coal-loading shovels also has been increased, and in some mines dippers of 7 cubic yards are in use.

The increase in the size of loading shovels brought about the installation of larger haulage units, and in some mines 50-ton-capacity cars are used. Truck haulage has been found economical in some operations, and these also show the trend toward greater output. Truck and trailer units having a capacity of 25 tons are in use and units of 40-ton capacity are being built.



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As greater thicknesses of overburden are being removed, the manufacturers of stripping equipment have been able to meet the situation with shovels of greater reach and capacity. From the progress made in the last few years it would seem that the engineering problems arising in the design of this larger equipment will be met, and no forecast can be made as to the limit in size of these units.

Mechanical coal cleaners are part of the tipple equipment at some strip mines, and where these devices were used at the mines visited they were of the wet type. The use of washeries reduces the time and labor that would otherwise be required for careful coal cleaning in the mine and is comparable to the installation of cleaning plants at underground mines. At one operation visited there is a central cleaning plant that prepares coal from both strip and underground mines. Coal beds with similar physical characteristics can be mined as clean in strip mines as in underground mines where the coal is loaded mechanically.

The total cost of shovels and equipment (exclusive of tipple and cleaning plant) recently installed at a large stripping operation was approximately three-quarters of a million dollars. About five years ago an average size stripping operation was equipped at a cost of approximately half a million dollars, which included all machinery and equipment except the tipple.

The following table summarizes the principal features of the shovels and draglines employed at the several mines herein described.



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TABLE 2.- Stripping shovel and dragline data

| Mine | Working weight, tons | Dipper capacity, cu. yds. | Boom length, feet | Length of dipper stick, feet | Power, steam or electric | Mounting |
|---|---|---|---|---|---|---|
| 1 | 365 | 6 | 80 | 56 | Steam | Wheel mounted on rails. |
| 1 | 365 | 6 | 80 | 56 | do. | Do. |
| 2 | 327 | 6 | 80 | 58 | do. | Do. |
| 3 | 1,500 | 16 | 97.5 | 64 | Electric | Crawler. |
| 4 | 300 | 6 | 90 | 54 | Steam | Wheel mounted on rails. |
| 4 | 300 | 6 | 90 | 54 | do. | Do. |
| 5 | 1,250 | 30 | 105 | 72 | Electric | Crawler. |
| 6 | 925 | 17 | 95 | 64 | Electric | Crawler. |
| 6 | 1,000 | 22 | 85 | 60 | Electric | Crawler. |
| 7 | 925 | 12 | 95 | 64 | Electric | Crawler. |
| 8 | 1,550 | 32 | 102.5 | 69 | Electric | Crawler. |
| 8 | 1,000 | 17 | 90 | 68 | Electric | Crawler. |
| 8 | 1,000 | 17 | 90 | 68 | Electric | Crawler. |
| 8 | 950 2/ | 14 | 170 | 2/ | Electric | Crawler. |
| 8 | 950 2/ | 14 | 170 | 2/ | Electric | Crawler. |
| 8 | 625 2/ | 9 | 150 | 2/ | Electric | Crawler. |
| 9 | 1,750 | 15 | 120 | 84 | Electric | Crawler. |
| 9 | 1,000 | 15 | 90 | 64 | Electric | Crawler. |
| 9 | 1,000 | 15 | 90 | 64 | Electric | Crawler. |
| 9 | 950 2/ | 12 | 170 | 2/ | Electric | Crawler. |
| 9 | 950 2/ | 14 | 170 | 2/ | Electric | Crawler. |
| 10 | 1,000 | 18 | 95 | 64 | Electric | Crawler |
| 11 | 1,410 | 23 | 97 | 56 | Electric | Crawler. |
| 12 | 775 | 12.5 | 95 | 58 | Electric | Crawler. |
| 12 | 200 | 4 | 29.5 | 21.5 | Electric | Crawler. 1/ |
| 13 | 675 | 12.5 | 95 | 58 | Electric | Crawler. |
| 14 | 1,000 | 20 | 92 | 60 | Electric | Crawler. |
| 14 | 730 | 13 | 95 | 53 | Electric | Crawler. |
| 15 | 327 | 6 | 80 | 58 | Steam | Crawler. |
| 15 | 219 2/ | 6 | 125 | 2/ | Electric | Wheel mounted on rails. |
| 16 | 1,100 | 18 | 95 | 64 | Electric | Crawler. |
| 17 | 755 | 15 | 87.5 | 56 | Electric | Crawler. |
| 18 | 1,000 | 20 | 87 | 62 | Electric | Crawler. |

1/ When car transporter is used, this shovel is used for loading spoil into car transporter. 2/ Dragline.



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TABLE 3.- Loading shovel data

| Mine | Working weight, tons | Dipper capacity, cu. yds. | Type of dipper | Power, steam or electric | Mounting |
|---|---|---|---|---|---|
| 1 | 55 | 1.5 | Standard | Steam | Crawler. |
| 1 | 55 | 1.5 | do. | do. | Crawler. |
| 2 | 55 | 1.75 | do. | do. | Crawler. |
| 3 | 85 | 3.0 | Coal loading | Electric | Crawler. |
| 4 | 55 | 1.5 | Standard | Steam | Crawler. |
| 4 | 55 | 1.5 | do. | do. | Crawler. |
| 5 | 104 | 3.25 | Coal loading | Electric | Crawler. |
| 6 | 76 | 3.5 | Coal loading | Electric | Crawler. |
| 6 | 104 | 5.0 | Coal loading | Electric | Crawler. |
| 7 | 104 | 3.5 | Coal loading | Electric | Crawler. |
| 8 | 80 | 3.0 | Coal loading | Electric | Crawler. |
| 8 | 95 | 4.0 | Coal loading | Electric | Crawler. |
| 8 | 95 | 4.0 | Coal loading | Electric | Crawler. |
| 8 | 170 | 7.0 | Coal loading | Electric | Crawler. |
| 9 | 100 | 4.25 | Coal loading | Electric | Crawler. |
| 9 | 100 | 4.25 | Coal loading | Electric | Crawler. |
| 9 | 100 | 4.25 | Coal loading | Electric | Crawler. |
| 10 | 112 | 5.0 | Coal loading | Electric | Crawler. |
| 11 | 76 | 4.5 | Skimmer | Electric | Crawler. |
| 11 | 100 | 9 tons | Derrick | Electric | Crawler. (90-foot boom) |
| 12 | 100 | 2.75 | Coal loading | Electric | Crawler. |
| 12 | 43 | 1.5 | Coal loading | Gas-electric | Crawler. |
| 13 | 100 | 2.75 | Coal loading | Electric | Crawler. |
| 14 | 76 | 2.75 | Skimmer | Electric | Crawler. |
| 14 | 135 | 5.0 | Coal loading | Electric | Crawler. |
| 15 | 28 | 1.5 | Skimmer | Steam | Crawler. |
| 15 | 28 | 1.5 | do. | do. | Crawler. |
| 16 | 103 | 3.0 | Coal loading | Electric | Crawler. |
| 17 | 76 | 2.75 | Skimmer | Electric | Crawler. |
| 17 | 77 | 4 tons | Derrick | Electric | Crawler. (71-foot boom) |
| 18 | 105 | 4.5 | Skimmer | Electric | Crawler. |
| 18 | 100 | 10 tons | Derrick | Electric | Crawler. (80-foot boom) |



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## CONCLUSIONS

The following conclusions have been drawn from experience gained at the mines described and apply principally to the areas in which these mines are situated.

1. Each area that has been proven minable for stripping by extensive exploration presents a separate problem. Both stripping and loading equipment must be suited to the conditions known to exist in the area and for the desired annual tonnage. The size of the units should be balanced efficiently. Since demand for coal is seasonable, the mine layout and design of equipment should be such that maximum production can be attained when the demand is the greatest.

2. One of the principal factors upon which the success of a stripping operation depends is the ability to uncover coal, since the production is limited by the amount of coal uncovered. This means that the stripping equipment must move maximum yardage. Any delay reduces the yardage and, hence, the coal uncovered. Reduction in effective working time is due sometimes to size of the fragments in the broken overburden. A study should be made of the character of the overlying strata, and experiments should be conducted on size and spacing of drill holes, and kind and amount of explosives with the object of obtaining maximum fragmentation. More yardage can be stripped when the material is broken into sizes that can be handled easily. It is possible for the total drilling and explosives cost to increase but the cost per yard of overburden moved, and thus the cost per ton, to decrease.

3. It is the opinion of the authors that no figure can be set for the maximum economic depth of stripping or for the maximum overburden-coal ratio. These limits depend upon a number of factors, some of which are as follows:

(a) Location of the mine with reference to markets: Freight differentials may make it possible to mine at higher ratios than at mines less favorably located with respect to market.

(b) Selling price of the coal.

(c) Character of the overburden: If the overburden is composed of a large percentage of hard strata requiring blasting, a high drilling and blasting cost will result, which may increase the mining cost to an unprofitable figure.

(d) Annual tonnage: In thin seams the recovery per acre is less than from thick seams, and more yardage must be handled to uncover a given tonnage. This entails an investment in large-capacity equipment that must be depreciated and amortized during the life of the mine. The assigned acreage must, therefore, be larger for a thin seam than a thicker one for the same tonnage reserve. Mining an area containing a thin seam necessitates the maintenance of long pits and haulage roads to obtain a large annual tonnage in order



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that fixed charges may be reduced. This may or may not be feasible. Also, thick seams and high ratios mean a large investment and, consequently, the necessity for large tonnage reserves.

Since the maximum economic depth of stripping is unknown, the stripable coal reserves in any district cannot be estimated with certainty. Although the reserves of known areas of stripable coal have been greatly depleted in some States, the Illinois State Geological Survey in 1925 estimated the strip coal reserves in Illinois at 1,407,000,000 tons.6/

Prospecting for coal beds that can be mined by stripping is being carried on systematically, and new areas have been found that greatly increase the tonnage available for this type of mining. It does not appear that strip coal mining is a dying industry but will continue to compete with underground mining for some years.

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6/ Culver, Harold E., Preliminary Report on Coal Stripping Possibilities in Illinois. Division of the Illinois Geological Survey Cooperative Mining Series Bulletin 28, 1925, p. 17.



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